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ADELAIDE

PHILOSOPHICAL

SOCIETY.



ANNUAL REPORT & TRANSACTIONS

FOR THE YEAR ENDING 30TH SEPTEMBER, 1870.

ADELAIDE:
PRINTED BY ANDREWS, THOMAS, & CLARK, GRENFELL STREET.

1871.

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HIS EXCELLENCY SIR JAMES FERGUSSON, BART.

VICE-PRESIDENTS :

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F. G. WATERHOUSE.

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J. HOWARD CLARK.

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J. S. LLOYD.

ADELAIDE :

PRINTED BY ANDREWS, THOMAS, & CLARK, AT THE "REGISTER," "OBSERVER," AND "JOURNAL" OFFICES,
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1871.

Adelaide Philosophical Society.

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17th Nov. 1905.

REPORT

OF THE

COUNCIL OF THE ADELAIDE

PHILOSOPHICAL SOCIETY,

PRESENTED 18th OCTOBER, 1870.

The Council of the Adelaide Philosophical Society have pleasure in presenting their seventeenth Annual Report of its proceedings.

There is little of striking interest to call attention of members to in the history of the Society's transactions during the past year; but the Council are still impressed with the conviction that this Society occupies a position of much use and importance to the colony.

During the past year eight meetings have been held, when the following subjects have been brought before the Society's notice:—

- "Irrigation," by Mr. C. S. Hare.
- "The Camel in South Australia," by Mr. J. S. Lloyd.
- "The Botanic Families of the Cactæ and Palms," by Dr. Schomburgk.

"Currents of the Air and Sea" (3rd paper), by Mr. B. H. Babbage.

"Importance of Silk Cultivation as a branch of Colonial Industry," by Mr. T. S. Reed.

"Remarks respecting the Erection of a Telegraph Line directly across the Continent, from Port Augusta to Port Darwin," by Mr. C. Todd.

"Light Railway Construction," by Mr. R. C. Patterson.

"Influence of Forests on Climate," by Dr. Schomburgk.

"Observations on the Palæontology of Australia," by Mr. F. G. Watherhouse.

"Light Railway Construction," by Mr. A. F. Lindsay.

Mr. D. Adamson exhibited diagrams of some large spots seen in the sun's disc through the excellent reflecting telescope made by himself.

Messrs. R. C. Patterson and A. W. Dobbie have been elected members of the Society during the past year.

The following donations have been made to the Society during the past year, viz.—Journal of the Society of Arts, and the Melbourne Observatory Astronomical Results, vol. III. Advice has also been received of some valuable works sent by the Smithsonian Institute, Washington, which doubtless will shortly come to hand.

The Council wish to impress upon members the necessity of paying their subscriptions punctually; during the past year, out of sixty-seven ordinary members, it appears only thirty-nine have paid their annual subscriptions.

THE TREASURER IN ACCOUNT CURRENT WITH THE ADELAIDE PHILOSOPHICAL SOCIETY.

Dr.				£	s.	d.
October 1st, 1869—						
To Balance in hand as per last account	...	...	...	24	6	9
September 30th, 1870—						
To amounts received, viz.	...	...	...	5	5	0
Arrears of Subscription	...	...	...	45	3	0
Subscriptions for current year	...	...	...	50	8	0
				74	14	9
To S.A. Institute on account of sale of the Royal Society's transactions	...	...	...	16	16	0
				£91	10	9

E. & O. E.
Adelaide, 1st December, 1870.
JNO. HOWARD CLARK, Treasurer.

Examined and found correct,
J. S. LLOYD.

Cr.				£	s.	d.
September 30th, 1870—						
By Sundry Expenses, viz:—	Contributions to S.A. Institute—	...	...	16	16	0
	one-third of £50 8s.	...	...	13	10	6
	Printing and advertising notices of meetings	...	...	34	13	6
	Printing report and transactions	...	...	3	17	8
	Postages and petty expenses	...	...	68	17	8
By Balance	...	...	...	22	13	1
				£91	10	9

PAPER READ BY MR. C. S. HARE, ON TUESDAY, OCTOBER 19, 1869.

SUBJECT—“IRRIGATION.”

In offering you a few thoughts on the subject of Irrigation, I shall by way of introduction refer to systems of Irrigation adopted and which have been adopted in other countries.

The most remarkable instance of the value of Irrigation in the productions of substances for human sustenance at present in existence is that of the River Nile. The valley of the Nile is about 800 miles in length, by an average of three miles in breadth, and this comparatively small space of country maintains more people than any similar space on the globe; and without applying the waters of the river by artificial irrigation, this space or area of land would not support an equal number of human beings to that of third class lands in the majority of inhabited countries.

It is not perhaps generally known, that great and surprising as are the efforts and the works for irrigation in Egypt, that they have been far surpassed in ancient times by an extinct people in the island of Ceylon. These with some existing are the past remains of vast Cyclopean works for that purpose.

In Sir J. Emerson Tennent's work on Ceylon, there are various notices of the remains of these vast works. He says that the Tank of Hiwara is a stupendous work—"a stream flowing between two lines of hills about three or four miles apart, has been intercepted by an artificial dam, drawn across the valley at the point where they approach and the water thus confined is thrown back till it forms a lake eight or ten miles long by three or four miles wide, exclusive of narrow branches running behind spurs of the hills. The embankment is from 50 to 70 feet high and 200 feet broad at the base. One of the most important and ingenious features of the work is the advantage which has been taken in its construction of two vast masses of rock, which have been included in the retaining bank, the intervening spaces being filled up by earth-work, and faced with stone. In order to form the sluices, it is obvious that the simplest form would have been to have placed them on the artificial portions of the bank, but the builders, conscious of the comparatively unsubstantial nature of their own (i.e. man's work) and apprehensive of the combined effect of the weight and rush of the water, foresaw that the immense force of its discharge would speedily wear away any artificial conduits they could construct for its escape, and they had the resolution to hollow out channels in the solid rock, through which they opened two passages each sixty feet deep, four feet broad at the bottom, and widening from fifteen to twenty feet at the top. The walls on either side still exhibit traces of the wedges by which the stone was riven to effect the openings. These passages had formerly been furnished with sluices for regulating the quantity of water allowed to escape, and the hewn stones which retained these flood-gates lie displaced in the bed of the channel.

"The Tank of Padavil, the remains of it also seem to have been a stupendous work; the bund or bank nearly eleven miles in length, thirty feet broad at the top, and about two hundred feet at the base, and upwards of seventy feet high, and faced throughout its extent by layers of squared stone. The existing sluice of the vast work is remarkable

not only from its dimensions, but from the ingenuity and excellence of its workmanship. It is built of layers of hewn stone varying from six to twelve feet in length; these rise into a ponderous wall immediately above the vents which regulate the escape of the water, and each layer of the work is kept in its place by the frequent insertion endwise of long plinths of stone, whose extremities project beyond the surface, with a flange to key the several courses, and prevent them being forced out of their place."

Sir Emerson Tennent observes, "that when entire, the capabilities of this tank were so prodigious that it might be made to fertilize a district equal in extent to an English county." He further observes "that the population must have been enormous for whom the uses of such a tank might be adapted; the number of cubic yards in the bund is upwards of 17,000,000."

And further, "to show to what extent irrigation has been supplied in Ceylon, that in addition to 30 of these immense reservoirs, there are from 500 to 700 smaller tanks distributed over the face of the country, the majority in ruins (probably through ancient wars), but many still in serviceable order."

I will trouble you only with two small extracts more, to show somewhat the nature of the construction and durability of these works. He says "that in forming the bunds of these reservoirs, and the stone dams which they threw across the rivers to supply them with water, they were accustomed with incredible toil, infinitely increased by the imperfection of their tools and implements, to work a raised moulding in front of the blocks of stone, so that each course was retained in position not alone by its own weight, but by the difficulty of forcing it forward by pressure from behind."

As to the durability of such workmanship, he remarks, that "independently of the fact that vast numbers of these tanks though utterly deserted, remain in this respect almost unimpaired to the present day—and their own historians evidence that for upwards of 15 centuries the reservoirs when duly attended to, successfully defied all the dangers to be apprehended from wear, tear, and inundation—these latter probable injuries are the most to be feared in consequence of the heavy rains of tropical climates; the force and suddenness of these cannot be described so as to be understood by any except they have had experience of their effects."

It may be an interesting question for the historian and physiologist to inquire who were the people, and of what race were those mighty masons and engineers, who constructed these vast and eminently useful structures. The present inhabitants of the country do not seem to be able to have the brain capacity to perform, much less design, these structures. I think the race must have passed away, as is evidently the case in New Caledonia—where cognate works have lately been discovered. On my visiting New Caledonia lately, a similarly constructed tank to those described by Sir Emerson Tennent was discovered; the particulars of which I will shortly relate.

There are two large sugarloaf-shaped mountains, a few miles distant from the Port of Numea, connected together by a low saddle; nearly on the

top of one of these, viz., Mount d'Or, there is a large spring of water, which now finds its way down a rocky gully and water-course to the sea. The French engineers employed by Napoleon were endeavouring to construct a road into the interior of the mountain land, by way of the saddle that connects these two mountains, when they came across the filled-up remains of a vast stone tank, constructed of large hewn stones, in which, like the Ceylon tanks the stones were void of mortar, and retained one on the other by rebating the upper into the lower course. It was found on more complete examination that this vast tank, which looked like a lake, had outlets on to the bosom of both these mountains, allowing the stored up waters to escape at regular intervals down the breasts of the mountains, insuring constant fertility to them and the valleys below. It may not be out of place to remark, that the present savage and degraded race are wholly unacquainted with the use of any metallic instruments, either copper or iron, nor have such been discovered—but the fact remains, there is the tank and its aqueducts, whose uses would alone grow in such a climate food for thousands of its inhabitants.

I have given you the history of these works in order to put this question—*If in climates similar to ours, without frosts, and a mean temperature of 60 Fahrenheit, ancient people constructed such works for irrigation, why should not we avail ourselves of these glorious examples for the growth of all we desire?*

Laver that, with water thus supplied, our land and climate would willingly and profitably produce many tropical and all intertropical growths, such as rice, sugar, coffee, cotton, tobacco, millet, &c. The example which I would specially note to you for your study, is one on a much smaller scale, and of European existence—I allude to that one in the Venetian or Austrian Alps—where the waters of the smaller rivers and larger gullies are dammed back so as to form reservoirs, but I allude more particularly to the mode of distribution under a system something like that of our District Council's: these dams are constructed, and the water let out at a rental to the proprietors of land, according to their requirements and acreage. You will see in all the chateaux and farm-houses numerous bell-towers; early in the morning the flood-gates are opened, the farm nearest the gate receives its supply of water, say for half-an-hour, at the end of which its bell is rung and the stream is passed on to the next proprietor, and so on until the day's work is done; on the following day, another series of farms are irrigated, and the next day another series, until the whole district is supplied with the life-giving fluid—each proprietor to pay to the commune a rate for the time the water is on. Now, why can't we do the same thing in South Australia? We have a climate more equable and warmer than Lombardy; there they grow rice, Indian corn, and miller, &c., to great perfection, and tobacco—the same as that of which the Swiss cigars are made.

I aver that we can do this thing if we like; if an act is introduced into our Legislature empowering District Councils to borrow money for this

purpose, I do not doubt but that such would be readily obtained, and that capitalists would readily invest in such undertakings.

We have all around the most ample means of storing our waters. Take for example the Brownhill Creek; a wall thrown across the creek about half-a-mile from Mitcham, of 300 feet in length and 30 feet in height, would store up the rainfall of twelve miles of country, which at the observed rate of rainfall would collect the enormous quantity of 3,990,720,000 gallons of water; or in other words, the waters collected from twelve square miles of country, if distributed as in Lombardy over six square miles of land on the plains, would produce the equal of three harvests in one year. It is startling, perhaps, but cannot the thing be done, and if done, how valuable the land and how prosperous the country!

I have roughly estimated that the thing could be done, and the waters distributed at the rate of one penny per 1,000 gallons, at which rate it would return for interest of money, in cost of construction and expense of distribution £16,000 per annum; what farmer in the plains would not gladly pay one penny per thousand gallons of water? What would he not grow with such water at such a price? Nor is the Brownhill Creek the only place where this arrangement can be made; the Fifth Creek and the Little Para is better adapted than any of the creeks on this side of it, and the Gawler or South Para has greater advantages in one place. I lately observed that a dam wall two hundred feet long by eighty feet high, would probably store up the waters falling over some thirty to forty square miles of land. Nor need my hearers be alarmed at the cost of construction, especially in the places I have pointed out as most suitable for the purpose. In England some dams of the most substantial kind have been constructed, and that, too, in places less advantageously situated than our gulches, and therefore more costly, at an expense of only £73,000 per million cubic feet of water.

I now come to a part of my subject at which and for which I may be laughed at. I expect it; but I think him a coward, who, when he sees or fancies he sees a great possible good, refrains from showing his visions and hopes because he may be laughed at. At any rate, with me, neither threat, or sneer, or jeer, will prevent me from exhibiting to you my hope.

"My thought by day my dream at night" of bringing the vast waters, and at present nearly useless waters of the Murray into and on the whole of the thirsty plains of Adelaide, from the Burra to the Port.

I know very well that there are difficulties to be encountered, but these difficulties are not so formidable as at first sight they may appear. I know very well that these waters will have to be lifted by engine power from the river into trunk channels or canals of communication.

From what I know of the country between the north-west bend of the Murray and the Burra Burra, I think the waters will have to be lifted thrice, so as to gain a summit by which they may pass on to the lands to be irrigated. I think the first will require a lift of less than 100 feet; the second lift will require to be 200 or 250 feet; the third the same, or a little more, say 300 feet. After having attained this elevation, it may be necessary to tunnel instead of lift, and it is possible that two tunnels may be required, each of a mile in length; but these need not be much larger than the tunnel in use for conveying the waters of the Plenty into the Yarra Yarra reservoir, at Melbourne. This might probably cost £12,000 per mile; if three such miles were required, it would be no sufficient barrier to the work.

My auditors, though philosophers, may stand aghast at the expense and magnitude of the work, but they must look at the magnitude of the results; and it is now my duty to make it plain, that not only can it be done as an engineering work, but that when done it can be made to pay, commercially, and prove a good investment for capital. And here the question will arise, how much will it cost the consumers per 1000 gallons? Why, one penny a 1000 gallons will be a fortune to the undertakers of the work.

That it can be done, as an engineering fact, let us take a cognate one, the draining a lake or mere.

The once great lake of Haarlaem in Holland, has been drained, i.e. pumped away. The lake was 14 miles long by 10 miles broad, the area 70 square miles, average depth 13 feet 1 inch. To do this a Cornish engine was built, whose cylinder was 144 inches in diameter; it raised 112 tons of water at each stroke, and was capable of discharging 1,000,000 tons of water in 25 hours, or say 240,000,000 gallons in a day of 24 hours.

The cost of this wonderful engine, machinery and buildings, was only £36,000.

I cannot find the evidence as to the working costs of this engine per 1000 tons of water, but I infer that it must have been worked cheaper than any other smaller sized engine; but I have some reliable data to offer to your notice respecting these smaller engines.

The London water engine has a cylinder of 100 inches, with 11-foot stroke, makes six strokes per minute, and raises 150 feet cube of water per stroke, or nine millions of gallons in 24 hours, at a cost of 12s. 6d. per million gallons, raised 100 feet high.

I had some doubt about the correctness of this statement, but I found it true; on taking a great deal of trouble to ascertain the results of other engines, Mr. Wickstead, of the East London Water Works, has published a similar fact—that by his engine, the "Wickstead," the cost is only one shilling for every 80,000 gallons of water raised 100 feet, that is, for wages, coal, oil, hemp, waste, and repairs.

Great as is the performance of these engines—and at Liverpool the same results have occurred, the pumping having been done at a cost of a little less than 12s. per million gallons—greater performances have been achieved by Mr. McAlpine, at the Brooklyn Works, in New York, where for 13s. 2d. water is raised 190 feet per million gallons; such an engine, &c., as this would be required for the second and third lifts. Now these engines, with their buildings, and appliances, have cost less than £35,000 each. Such sums as these should not deter us from the experiment, supposing that four such engines are needful: the cost of working here will be little more than the cost of working in England, the chief item, firing, will be to be had sufficiently cheap, three tons of the Murray scrub fire-wood being equal to one ton of coals; but supposing wages and fuel costs double what it does at home, and that two shillings has to be paid instead of one shilling for raising 80,000 gallons of water, will not that pay?

The next great cost will be the canal, or rather channel for distribution: this, in the first instance should be a small one, and yet sufficiently, where the ground is easily wrought as to act reservoir, and contain quantity, so that the winter pumping being thus stored, may add to that pumped daily in the summer, for daily and hourly distribution of seven months of the year.

The channel, as I have before observed, where the ground is favourable for the work, should be large enough to act as a reservoir. I think it should be twelve feet wide at the top, six feet wide at the bottom, and six feet deep. Thus—



This form of channel has been found easiest to keep clean, and cheapest in construction, and if

of this size will contain in every mile forward 1,782,000 gallons per mile; and, for the water to move sufficiently rapid, should have a fall from the source of four inches to the mile. This might cost, taking one piece of country with another, £3,000 per mile, exclusive of the two tunnels which I indicate may be necessary; these may cost £10,000 per mile.

I think I may not unfairly summarize the costs thus:—

4 engines with buildings and machinery	
£30,000 each	£120,000
2 tunnels, £10,000 each	20,000
100 miles of channel, at £3000 per mile	300,000
Aqueduct bridges	60,000

or £5,000 per mile. £500,000

Let us compare this supposed cost against the actual cost of the Port and Kapunda Railway, which has cost the country £13,500 per mile, and ask the question, which is likely to be the remunerative work—the one which doubles the crop—and adds to those at present existing sugar, cotton, tobacco, rice, Indian corn, and in fact all tropical productions—or that work which at present is principally confined to bringing to market our wheat crops of 11 bushels per acre. Should irrigation take place in the way I have indicated, then indeed there would be full employment for the railway, in taking the immensely increased products to our Port for shipment.

The performances of the Wickstead engine alone is quite enough data for me to bring before you in the first instance, to induce you to study, and through you the country to study, the whole question of irrigation, and of ultimately bringing the Murray through our plains making them still more fertile, until "they shall rejoice, and blossom as the rose." Looking far into the future—how great would this be if the waters of the river so pelleted and soft were brought hitherto for farming purposes, and much greater would it become if its waters also in a navigable form were introduced. It is not impossible; it would drain the whole commerce of our vast interior into our very lap; and though I cannot hope to see the day in which this glorious achievement may be attained, I trust that some who hear me, some of the rising generation, may rejoice in its varied and manifold blessings, and will love to dwell in the Eden that this will be, rejoicing in life as those that dwell always "in the Garden of the Lord."

ADDENDA.

Since the foregoing was written two important and interesting facts have turned up, confirming my views of the importance and necessity of applying a scheme of Irrigation to this country.

1st. The Minister of Agriculture in France has published an official document on the success of his scheme of Irrigation, as applied to the French colony of Algeria—Algeria being a climate exactly similar to that of South Australia—in fact, a little more arid and a little less rainy, i.e., an average of 16 inches of rain there against 18 inches of rain as the mean of South Australia. The French Minister declares that, by conserving the waters from the hills, he has applied Irrigation to the plains, producing lucerne which is now cut every fifteen (15) days, 18 inches high each cut.

2nd. The last number of the *Builder* for December, 1889, quotes from the *Indian Economist* an article headed "Does Irrigation pay?" and it affirms that the north-western provinces of India have been saved by the Government plan of Irrigation, which has cost two millions of money, irrigating 1,040,295 acres, from which 38½ bushels of wheat have been harvested, besides fodder for cattle, and that the money value of said crop on the ground is eight millions sterling—feeding three millions of people; thus recouping in one season the first cost four-fold.

If the Irrigability can be thus turned to account, cannot the Mississippi of Australia be forced by science and capital to do the same thing?

PAPER READ BY MR. J. S. LLOYD, ON TUESDAY, NOVEMBER 16, 1869.

SUBJECT—"THE CAMEL IN SOUTH AUSTRALIA."

Before proceeding with the subject of my paper, I should like, by way of introduction, to say a few words on the general subject of acclimatization, which in this colony and at the present time ought to claim the special attention of the Adelaide Philosophical Society. It does not at all follow that because we have here no Acclimatization Society, we have therefore no acclimatization going on. It goes on slowly, perhaps, in comparison with what it might or ought to do; but we can see that still it does go on, silently, perhaps, or if casually noticed in a newspaper local paragraph, soon forgotten. It is sometimes laid to our charge as a Society that we do not take up subjects of sufficient public or practical interest, and that this is the reason why our meetings are neglected, and why general interest in our proceedings fails. I do not think the charge is altogether fair or well deserved; but here, at any rate, is a subject both of public and practical interest, which we may well take up, to the manifest advantage of the colony and of the Society itself at the same time. I do not know that I need do more than allude to the efforts made from time to time to form here an Acclimatization Society, on a basis similar to that of the Society which flourishes so vigorously in Melbourne. They originated with this Society, and it was a Committee of this Society which took the preliminary steps towards a scheme which at one time promised success. The ultimate failure of these endeavours naturally places the subject under our cognizance again, and I for one should be glad if a sufficient amount of interest were shown in it by our members to enable us to form a Committee charged to report upon the subject from time to time, or say at least once in the year. Some time since, when in Melbourne, I called on Mr. Spriggs, the Secretary of the Victorian Acclimatization Society, and obtained from him the annual reports of their Society from the commencement, which will, I feel sure, be found interesting to any member who takes the trouble to look into them. Mr. Spriggs showed me over the Royal Park, where the animals are kept on arrival in the colony, and it was pleasant to see the hares running about the enclosure, as well as many other strange animals and birds which are thriving in an Australian climate. He also mentioned that they would be glad to assist us, and that if any money was subscribed or voted, and was handed to them for expenditure on any particular objects, they would allow us to avail ourselves of their machinery for the purpose of obtaining and bringing such objects to the colony, and it appears that they have an agent constantly employed going backwards and forwards to and from England in bringing out animals and birds. I promised him to bring his kind offer, when I returned, to the notice of the Society of which I was Secretary, hoping that we should see some way of making good use of it; and, although I have mentioned the subject before, it may not be out of place for me to call the attention of the members of our Society to it on the present occasion.

To me it appears that the duty of keeping the importance of the continual introduction of new plants and animals into the country before the public is the most important function of any Acclimatization Society; for, without any discredit to these valuable Associations, wherever

established, it should always be remembered that the most important importations, whether of plants or animals, have ever been due to private enterprise. Their business is to point the road—sometimes to lead the way; but to do any real good or become of real importance, the movement must be taken up by private persons, and generally with some prospect of commercial returns or advantage to those who undertake the money advance. These remarks are true of all the animals at present in common use for service or profit, and therefore, without feeling it laid upon us as a Society to make arrangements for, or undertake the charge of importations of useful animals from other countries, we ought to endeavour to obtain the best information of what is being done with this object around us, and to place the history of all experiments and attempts of the kind upon our records.

I am inclined to believe that even without an Acclimatization Society we in South Australia are in advance of our neighbours in Victoria to the extent of the possession of larger numbers of three most important animals—I mean the camel, the ass, and the Angora goat. It is to the first of these that I propose to call your attention this evening. I should have much liked to refer to the others also, but am not at present sufficiently supplied with information. Of course, what I have to say about the camel can only be in the nature of compilation. I have no personal acquaintance with the animal, having seen, I think, only two living specimens; one I remember being a Bactrian or two-humped camel, and the other the young animal at present in the Botanic Garden under Dr. Schomburgk's care. I have thought, however, that the few particulars which I have obtained at first hand would prove interesting, as enabling a comparison to be drawn between the camel as he is in South Australia and the camel as he is described in books of travel and natural history in other countries; but it must not be forgotten that the experiment is yet but tentative, and that we cannot expect to obtain the full value of his settlement amongst us until he becomes as cheap, as widely dispersed, and as common as the bullock or horse.

I have been informed by Mr. Henry Phillips, of North Adelaide, that he and his brothers during their voyage to this colony called at the Canary Islands, and there purchased some (I believe nine) camels, one only being landed alive. This one afterwards became the property and travelling companion of one of the early settlers—Mr. Horrocks—who, I am given to understand, discovered the pass still known by his name in the North, near Mount Remarkable, and whose death by the accidental discharge of a gun was the occasion of the death of the camel by his order when dying. This was many years ago; but the tradition of this animal's character, powers, and capabilities was favourable to him; and ever since I think people have been prepared to find in the camel the beast of burden most suitable for the generally difficult and at times desert country and climate of the interior.

It is now more than three years since Mr. Elder imported a cargo of camels and asses from Kurrachee, the seaport of Scinde, to Port Augusta,

and the experience gained of the habits and capability of these camels for labour in these three years ought to be sufficient to enable a judgment to be formed of their ultimate value to these colonies. I may say that both their owner (Mr. Elder) and those who have had the care and charge of them since their arrival have formed a high opinion of their value, of their capacity for work, and of their suitability for many places and purposes where, or for which, cattle and horses could not be used. They have also been much impressed by their docility, but it is also fully understood that the persons who have to manage them must be educated or trained to their proper management. This is, however, only what those who now find it most easy to drive or to control horses or oxen have had to undergo, although often unconsciously, but which is sufficiently apparent when some new chum attempts for the first time to put together a team of bullocks for the first time to or, when they are put together in the stockyards, or, when they are put together by voice and stockwhip. So many horses and bullocks are in use, and the number of persons acquainted with their habits and accustomed to their management is so large, that the tyro has no difficulty in finding efficient teachers; but the camels, ever since their arrival in this colony, have been in the care of Afghan drivers, and to the bushmen of the North they are still objects of fear and wonder, only one or two of the white colonists having learnt to handle or manage them. The most remarkable feature in their treatment appears to me to be the absence of punishment. I am told the Arab drivers never beat them, and they have inculcated a very great, perhaps a wholesome apprehension of the dire results which would follow the use of the stick, to their English fellow-herdsmen and shepherds. And yet there is no doubt that in other countries a stimulus of some kind is applied, and Sir Samuel Baker mentions the hippopotamus hide whips used for the purpose upon the Upper Nile. An old bushman and friend of mine, Mr. Stephen Hack, now in England, writing about Mr. Elder's camels, says:—"I feel much interest about them. I do not believe in Englishmen (if properly selected) not being able to manage camels. Why, look back at the early days of the colony, when Jem Chambers tried to work the Cape working bullocks imported by Government—bullocks broke in to Dutch talk, and Dutch ways and gear. He could do little good with them until they were, as you may say, trained over again. I consider myself a first-class bullock breaker and driver; but on the South Downs, when staying at a friend's farm where they work oxen, I could do nothing with brutes trained to go if poked with a long stick."

I am chiefly indebted to the Messrs. Stuckey, lately of Umeratana, for such particulars of this important experiment as I have been able to gather to lay before you on the present occasion. One of these gentlemen, Mr. Samuel Stuckey, went to India to purchase the camels, and bring them down to South Australia. Out of 124, shipped at Kurrachee, 121 camels were landed in good condition; three died from cold, which produced inflammation of the lungs. They bore the voyage exceedingly well, and, fed upon native grass hay, and mong boosa, and cannic boosa (the chaff of rape and of wheat), they became too fat, and had to be placed upon a

short allowance. They were supplied with between two and three gallons of water daily each. No bedding was used, but the decks were covered with coir matting, to keep their feet from slipping. No partitions were used, either in the tween decks or the hold, the camels being merely fastened by the heads. Since their arrival in the colony the herd of 121 has been increased by births, in excess of deaths, to 160 at the present time; but I may here mention that a large number, about 70, died of disease, a kind of mange, to which they are subject in their native country, but which the natives there are able to cure by the use of vegetable oils, which they extract from various common herbs. Here much difficulty was found in ascertaining a remedy. Luxuriant feed augmented the disease from which they suffered. At length a cure was found, in the use of Stockholm tar applied externally and tar and oil internally, and these medicines are considered by the Arabs who attend them the best remedies they have seen. Bushes supplying the natural food of the camel, and his height, long neck, and peculiar mouth enabling him to reach and feed upon them at a height from the ground far above the reach of the horse and ox (both of which, too, prefer grass to bushes), he is able to live and flourish where these would infallibly starve. His powers of digestion also being like those of the ass, exceedingly strong, the character of his food is of comparatively small consequence. He will eat and enjoy saltbush, prickly acacia, bluebush, sandalwood, mulga, shea-ox, and, if hungry, will not flinch from mallee, wattle, or gum. or, so far as I can make out, from any tree that grows. Indeed, the great point of advantage with the camel seems to be that he can live, work, and do well where almost any other animal would be sure to starve.

I have not yet referred to that particular merit for which the camel is most widely famed, and which is its great recommendation to the people of hot and dry, and perhaps even more to those of uncertain climates—I mean its power of endurance under thirst, for which characteristic it is indebted to the peculiar formation of its stomach, which supplies a reservoir for the storage of water. In order to take advantage of this capability to the utmost it is necessary to train the camel to abstinence from drinking except at stated intervals; but so trained he will go from seven to eight days, or even more, without water and without much distress. His rider is thus enabled to travel with much more safety and confidence than the horseman. The latter on the evening of the second day after leaving water may well become anxious, knowing that it will test the strength of his beast to reach it again, and that even if he does get back the distress suffered will be such as to render his horse useless for weeks.

Mr. Elder imported camels of three different breeds, namely—The fast or Mekrana camel, for riding purposes; the hill camel from Scinde, suitable for riding or baggage, being the common camel of Western India; the hairy camel from Candahar—fine, strong, thick-set animals, eight, nine, and ten feet high, the best kind for heavy loads. The female breeds about four times in five years. The young are weakly for the first few days; but on gaining strength are very pretty and active. The dam gives a large quantity of beautiful milk, and allows herself to be handled like a cow. At the age of three years the camel has all its sucking teeth. At four years it sheds two teeth, and afterwards it sheds two teeth each year like sheep until it is full-mouthed, with eight teeth, at seven years old. At ten years it is in its prime—like a horse at say four years—and it lives to 40 or 50 years. Camels are broken in with very little trouble, and may be lightly loaded at three years old. On enquiring respecting the capability of the camel for burden I was informed that on one occasion sixty odd camels travelled from Umberatana with an average load of 593 lbs. of wool each. They travelled comfortably 17 or 18 miles per diem, and endured four and five days' thirst easily. For say one man for every ton of weight. I find, however, that camels may be made available for use in sugar-mills for drawing water, and they also do the work of bullocks in working mortar-mills. I was told of one gentleman in India who travelled with a pair of camels in his carriage,

driven by a postilion. In this colony a heavy camel carried an Afghani with the mail 350 miles in seven days. Mr. S. rode a camel 80 miles, from Puttapa to Umberatana, in one day, and thinks that 400 miles might easily be accomplished in five days on a riding camel. The latter travel at from seven to ten miles an hour for many hours together, but during hot weather they do not travel so well in the heat of the day as at night. At Port Augusta on one occasion, and in consequence of a bet between the men as to what one of the camels—a large one, seven years old—could do, ten bags of flour, or 2,000 lbs., were placed upon its back when kneeling, and it rose and carried this load without difficulty round the camp. The same camel drew six dead camels nearly a mile over sand, one at a time, with only a rope round its neck, and it has frequently drawn a 60-gallon bucket from a whip well. These instances were mentioned to show the power of this camel both for burden and draught.

Mr. Stuckey considers the camel the most docile of animals. Nearly 4 years' experience has shown him that vice occurs more seldom with camels than with ordinary stock, and that the only reason why Europeans cannot manage camels is the want of patience and experience on their part. They are exceedingly sure of foot, will travel over the most rugged places, and he has never known of a tender-footed camel. The only difficulty in the rearing and breeding of camels *ad libitum* inexpensively is the need of paddocks. Without paddocks they must be tailed, otherwise they will separate and wander in every direction; and, unlike other stock, they do not seem to attach themselves to any particular place or part of the country. It appears to be at the same time true that when excited to anger by ill-treatment, or other cause, the camel becomes a terrible antagonist. His attack is likely enough to end fatally for any man who is the object of it. His strength, long neck, height, weight, and some tremendous teeth or tusks, make it almost impossible for one man to beat him off, and he has an ugly habit of suddenly dropping on his knees upon the body of a prostrate enemy, which tends very much to reduce the chance of the latter's escaping with life. Indeed, I am assured that in an open plain escape from an infuriated camel is hopeless. One inconvenience in using camels in this colony is to be found in the difficulty of familiarizing horses and bullocks to their presence or neighbourhood, and in the terror which they always inspire at first. I do not know whether our stock are naturally wilder or more timid than those of other countries inhabited by camels, but I am given to understand that, however long the time that a horse may have worked or fed beside camels, he is certain to make a bolt if one of the latter fairly faces him, and will often do so if only looked at unexpectedly. I mention this, because I do not remember to have seen such difficulty mentioned in the references of travellers, either in India or Africa, where they certainly work and travel in company.

The camels have made a number of trips from Port Augusta, with stores for Northern stations, bringing down wool, which is packed in small bales for the purpose of easy handling and carriage, and is slung one bale on each side of a pack-saddle. During the early part of the year they carried stores through the Barrier Ranges to Mount Murchison on the Darling, to which point steamers had been unable to reach for a long period in consequence of the low state of the river. They made two journeys, and brought back a quantity of wool; but the river rising, their services were not further required. I have not been able to obtain any exact account of the weights carried, but they were four and five days without water at times, without injury or even distress. In support of Mr. Stuckey's information as to the capacity of the camel for draught, I may refer to a book recently published—Dilke's "Greater Britain"—where mention is made of a visit to Lahore when the author met the Commissioner or Governor of the Punjab driving out with a pair of camels in his carriage. Another point in favour of the camel is that unlike the tread of the horse, that of the camel does not destroy or disturb the surface of the ground upon which he travels. Its tendency is to improve the roads and to leave behind a good level well-beaten track. Captain McKay, who travelled in China, and went some distance beyond the Great Wall as an agent for Mr. Elder to obtain information about the

camels in use there, with a view to their importation, found the camels of that country bore a thick fleece of coarse hair, which, I believe, was regularly pulled or shorn at times, and formed an article of commercial value. The camels there are accustomed to a severe climate, ice and snow being usual at certain seasons; indeed, when he was there, Captain McKay suffered considerably from cold, and brought away a deafness, from which he did not recover for years. He considered that the Chinese camels would have been very suitable for this colony, but their transport was not quite so simple a matter as from India.

The expeditions of Burke and Wills, of McKinlay, and of Howitt were all accompanied by camels, and as they were not then attended by native drivers it is evident that there cannot be much real difficulty for white men in learning their management. McKinlay's expedition was accompanied by a flock of sheep, and the daily distance travelled was scarcely sufficient to enable the camel to compare to any great advantage beside the horse. The camels are also mentioned as suffering from sore feet, and it was found necessary to fit them with boots of hide or leather; but I believe McKinlay was favourably impressed with their power of endurance when fed upon the roughest or poorest scrub, and that his horses fell away in condition alarmingly and rapidly on several occasions, when the camels caused no anxiety on this account. The following extract is from "Tracks of McKinlay Across Australia," pages 63, 64:—"Both Burke and Wills and McKinlay had the novel addition of a troop of camels to the live stock of their respective expeditions. The Victoria Government, shortly before the departure of the former, had imported a number of camels from India; and their merits were thus promptly put on trial by the opportunity of the Victoria expedition. Of these Burke selected six with which to push on from Cooper's Creek, leaving the others, together with the bulk of the expedition, behind on the way. These camels, in fact, and but a single horse, were the sole attendants of his small party. McKinlay took four camels, in company of a good quadrupedal assemblage, consisting besides of 24 horses, 12 bullocks, and 100 sheep. The camel disputes with the horse the palm of usefulness in the Australian expeditions. In powers of endurance the camel seemed quite the equal of his rival; but he was more unruly and troublesome, and very uncompanionable with the other animals, his fellow-travellers. McKinlay found a decided convenience in the height of his back, as compared with that of the horse, in keeping the supplies of the party out of the water on the occasion of traversing the flooded parts of the march. But both horse and camel alike proved useful in other ways less premeditated. Necessity cures many prejudices, and hunger is a sauce to reconcile us to a very miscellaneous diet. As the stock diminished, and as the appetite increased, even horseflesh proved no unsavoury morsel, lean, tough, and jaded as it too often was. Horse after horse fell under the 'jerking' process, consisting of cutting the flesh into long stripes to be dried in the sun. The camel, too, took his turn under the knife, and our travellers were ever far more anxious to secure an adequate quantity than to differ about the quality of their fare. Only once was the case otherwise, when one of the camels, 'old and worn out with sores all over him,' was doomed to the knife and the jerking. Refractory even in the pot, the tough liver and kidneys defy the teeth of the hungry travellers, and the cook is enabled to boast for once on the journey that there was superfluity on the board."

Some camels imported by the Victorian Government were for a time stationed at the Royal Park, but they did not thrive. Many persons explained this by attributing it to the cold climate and exposed situation of the Park; but I think a cause is quite as likely to be found in the absence of the rough bush diet, of which the camel is so fond. When removed to the Wimmera District I understand they did much better.

In order to compare the camel in South Australia with the camel in those parts of the world which are considered its home, and also to supplement these few particulars upon points which I have omitted, I will, if time permits, read a few extracts from "Encyclopædia Britannica," "Buffon's Natural History," and also from a small volume published by the Useful Knowledge Society, containing a long article on the

camel, which will enable us to form some opinion of the value which may ultimately be placed on his services for burden and travel in Central Australia. The particulars I have gathered agree very closely with the description given in the "Encyclopædia Britannica," which is to the following effect:—"The camel attains its full strength at about the age of six years; lives about 40 to 50 years; only males usually employed for labour; females go with young about 12 months, and usually bring forth one at a time; found wild in deserts of Arabia, in Africa, and in most of the temperate parts of Asia. They are when trained made to go with apparent ease 300 leagues in eight days; will often run for even nine or ten days without water; can scent water at half a league; on journeys requiring speed they are allowed but one hour of the day for repose and for nourishment. In caravan travelling the large camels usually carry 10 or even 12 cwt; the smaller 6 or 7 cwt. In these commercial journeys they never hurry the camels in their march, but regulate their day's work say to 10 or 12 leagues every day; every evening load taken off, so that they may feed at liberty. If they are in a country abounding with herbage they usually eat as much in one hour as suffices for 24 hours, and during the rest of the night they ruminate. Delicate nourishment unnecessary. They prefer wormwood, thistles, nettles, broom, cassia, and other prickly plants to more pleasant herbage. So long as they find plants to browse upon they easily go without drink. During rutting season (say 40 days in spring) they are subject to fits of rage, and at other times when ill-treated they seldom fail to show their resentment."

The following extracts are taken from the Library of Entertaining Knowledge, published by the Useful Knowledge Society, Vol. I. of "The Menageries:—"

The Foot and Noiseless Tread of the Camel.—"The camel's tread is perfectly noiseless. The foot, composed of an elastic substance, and covered with hair, falls on the pavement in a manner very different from the rattling of the iron-shod horse. The large creature moves along under a heavy load with no greater noise than is made by the deer that bounds over the mossy turf." Mr. MacFarlane thus describes this peculiarity:—"What always struck me as something extremely romantic and mysterious was the noiseless step of the camel from the spongy nature of his foot. Whatever be the nature of the ground, sand or rock, or turf, or paved stones, you hear no foot fall; you see an immense animal approaching you still as a cloud floating on air, and unless he wear a bell your sense of hearing, acute as it may be, will give you no intimation of his presence."

Antipathy of the Horse to the Camel.—"We have noticed in the preceding chapter the terror which the horses of Pisa that have been unaccustomed to the camel feel at the unusual sight of this animal in the quiet performance of his laborious duties. This is not so in Smyrna and other parts of Asia. The horse and the camel are there constantly seen, each occupied in its respective labours; and horses in many cases form part of caravans—the horse carrying the traveller and the camel his luggage. We apprehend that this indifference in the horses in the East to the presence of the camel is an effect of hereditary habit. They have been domesticated together for many centuries, while at Pisa the introduction of the camel is comparatively of modern date. We are strengthened in this opinion by a curious passage in Herodotus, the Greek historian. He relates that when under the walls of Sardis, Cyrus met the Lydian army, commanded by Croesus, in order of battle. Fearing the cavalry of his enemy, he assembled all the camels which carried the baggage and provisions, and having taken off their loads, he put soldiers upon them, with orders thus to march against the cavalry of Croesus. Cyrus also ordered his infantry to follow the camels, and his cavalry to march in the rear of the infantry. He did this, says the historian, because the horse fears the camel, and cannot bear the sight or smell of him. Croesus depended for his success upon his cavalry; but the stratagem of Cyrus succeeded, for when the horses had smelt and seen the camels they became unruly and ran back. It may be inferred from this remarkable circumstance that the horse and the camel had not become familiar in the time of Cyrus; and, as we have sufficient testimony to the

fact of a like terror of the horse in our own times we may consider this peculiarity as one of the, many curious examples of the influence of domestication in changing or modifying the natural instincts of every animal."

The Camel's Load.—"Both ancient and modern authors agree tolerably well in their accounts of the load which a camel can carry. Sandys, in his 'Travels in the Holy Land,' says:—"Six hundred-weight is his ordinary load, yet will he carry a thousand." The caravans are distinguished as light or heavy according to the load which the camels bear. The average load of the heavy or slow-going camel, as stated by Major Rennell, who investigated the rate of travelling with great accuracy, is from 500 lbs. to 600 lbs. Burckhardt says that his luggage and provisions weighing only 2 cwt., and his camel being capable of carrying 6 cwt., he sold him, contracting for the transport of his luggage across the desert. Mr. Buckingham saw camels carrying mill-stones to the large towns on the west of the Jordan, each of which was nearly six feet in diameter; and one being laid flat on the animal's back, in the very centre of the hump, and resting on the high part of the saddle, was secured by cords passing under his belly. The camel sometimes carries large panniers, filled with heavy goods; sometimes bales are strapped on his back, fastened either with cordage made of the palm-tree or leathern thongs; and sometimes two or more will bear a sort of litter, in which women and children ride with considerable ease. The animal is so docile and steady, so regular in his movements and precise in his steps, and withal so capable of sustaining a very large and unwieldy burthen, that his driver seldom hesitates about the bulk or the awkwardness in any other way of what he places on his back. But the patience of the camel in bearing every sort of load, and his uncomplaining nature when overburthened, sometimes lead to oppression. He is occasionally too heavily weighted; and though there prevails an opinion that he will not rise with too great a load, he often sinks under his burthen and expires."

Pace of swift Dromedary and Distance he can Travel.—"Purchas, writing two centuries ago of the three sorts of camel, says:—"The third sort, called Raguel, is meagre and small, able to travel (for they are not used to burdens) above 100 miles in a day; and the King of Tombuctoo can send messengers on such camels to Segelmesse or Darha, 900 miles distant, in seven or eight days, without stay or change by the way." This is a statement which we might conceive to be exaggerated if we were to assume the speed and endurance of the horse as points of comparison. But the creatures are essentially different, and the relation of the old geographer is borne out by unimpeachable testimony. The Raguel of Purchas is the Heirel or Maherry of the desert."

Mounting the Camel.—"The first experiment which a European makes in bestriding a dromedary is generally a service of some little danger, from the peculiarity of the animal's movement in rising. Denon has described this with his usual vivacity. During the French invasion of Egypt, a part of Desaix's division, to which the scientific traveller was attached, was sent with camels to a distant post across the desert. The bonte-selle (the mounting at a signal) was very amusing. The camel, slow as he generally is in his actions, lifts up his hind legs very briskly at the instant his rider is in the saddle; the man is thus thrown forward, a similar movement of the fore leg throws him backward. Each motion is repeated, and it is not till the fourth movement, when the camel is fairly on his feet, that the rider can recover his balance. None of us could resist the first impulse, and thus nobody could laugh at his companions." Mr. MacFarlane tells us in his letter that upon his first camel adventure he was so unprepared for the probable effect of the creature's rising behind, that he was thrown over his head, to the infinite amusement of the Turks, who were laughing at his inexperience."

Camel Food.—"The expense of maintaining these valuable creatures is remarkably little; a cake of barley, a few dates, a handful of beans, will suffice, in addition to the hard and prickly shrubs which they find in every district but the very wildest of the desert. They are particularly fond of these vegetable productions which other animals would never touch, such as plants which are like spears and daggers in comparison with the needles of the thistle, and which often pierce the incautious traveller's boot. He might wish such thorns

eradicated from the earth, if he did not behold the camel contentedly browsing upon them; for he thus learns that Providence has made nothing in vain. The sant-tree is amongst these substances, and in this the camel especially delights. These hard shrubs probably contain large quantities of saline matter. In the Great Desert Riley saw the camels crop off the thornbushes as thick as a man's finger. Their teeth are peculiarly adapted for such a diet. Differing from all other ruminating tribes they have two strong cutting teeth in the upper jaw, and of the six grinding teeth, one on each side in the same jaw has a crooked form; their canine teeth, of which they have two in each jaw, are very strong; and in the lower jaw, the two external cutting teeth have a pointed form, and the foremost of the grinders is also pointed and crooked. They are thus provided with a most formidable apparatus for cutting and tearing the hardest vegetable substance. But the camel is at the same time organized so as to graze upon the finest herbage and browse upon the most delicate leaves, for his upper lip being divided he is enabled to nip off the tender shoots and turn them into his mouth with the greatest facility. Whether the sustenance, therefore, which he finds be of the coarsest or the softest kind, he is equally prepared to be satisfied with and to enjoy it."

Abstinence from Water.—"Upon the subject of the camel's power of abstinence from water, there have been many exaggerations, which Burckhardt ascribes to the credulity of those travellers who draw their information only from bragging Arabians and Moors. This power, however, is extraordinary enough to excite our wonder and admiration without any assistance from fanciful description. The camel often travels three and four days without water, drinking 50, 60, or even 100 pounds weight, when he has an opportunity, and the best camels for transport will sometimes endure a thirst of 10 or 12 days, though many of them perish under this privation. When we see what the man and the horse require in those arid countries, such a power in the camel must appear one of the most remarkable provisions of nature."

The Camel on Sand and Stones.—"Whatever be the nature of the road they toil over, they plod steadily on. Burckhardt says:—"It is an erroneous opinion that the camel delights on sandy ground. It is true that he crosses with less difficulty than any other animal; but wherever the sands are deep the weight of himself and his load makes his foot sink into the sand at every step, and he groans and often sinks under his burden. It is the hard gravelly ground of the desert which is most agreeable to this animal." Major Durham says that in the Stony Desert "the sharp points bruise their feet, and they totter and fall under their heavy burdens." This is an apparent and not a real contradiction between these two excellent authorities. The foot of the camel is adapted to tread upon a smooth surface, whether that surface be hard or soft. The camel, having a very large spreading and elastic foot, moves with ease over any smooth surface, and does not sink into the sand with his heavy lading and his large body in the same way that he would if his foot were small and hoofed as that of the horse."

The Camel's Peculiarities.—"Mr. Russell, the special correspondent of the *Times*, thus writes of the camel, from India:—"The *utilis* was never so little mingled with the *dulce* as in the instance of the camel. He is a horribly necessary animal, ungainly in his gait, disagreeable in his disposition, misanthropical and dyspeptic, and teetotal in his habits, sharp and unrelenting in his bites, of unaccountable fantasies in his likings and dislikings, unreasonably susceptible of pressure and oppression—a sort of inborn animal democrat, of a querulous and morose turn of mind, and possessed of the power, which he delights to use, of making the most horrible noises with his throat, his jaws, his tongue, and his stomach. With loud protestations they submit to monstrous cruelties from their keepers, and bite innocent and well-meaning people who are like to take an interest in them. They will allow, without anything more than a grunt, their leader to tear open their nostrils with a jerk of the string which is passed through the cartilage. Ten to one they will spit at you spitefully if you approach to offer them a piece of bread. They will march for days, the nose of one fastened to the tail of another in endless procession, and never seek to escape from bondage; and yet

the same creatures will gnash their tusks awfully at an unhappy European who ventures to rub their rugged sides. However, they form an institution of India—possibly a part of the traditional policy—and they must be respected accordingly." Mr. Russell, however, does not attempt to depreciate the services of the camel as a beast of burden in an arid country, and its usefulness in this capacity can hardly be doubted in the face of the experience of centuries, and of that of the inhabitants of so many hot countries. Indeed, all accounts seem to unite in attributing to the camel everywhere the traditional characteristic of patient endurance, as contrasted with the generous courage and impetuosity which are with equal unanimity attributed to the horse.

I think I have said enough to show that a time may come when the camel will be in this colony as numerous, as cheap, as common, and easily

managed as the ox or bullock, and when the ordinary bushman will be able to explore with his assistance, without difficulty or expense, every portion of this island continent, and to travel with ease, and alone, from east to west, and from south to north. There is still a large portion of the North-West which is utterly unknown, but which might easily become known by the help of camels. Overland roads to Western Australia and to North Australia are required, for although the latter has been traversed, we know too little about the permanent waters to make the journey safe for small parties or rapid travelling. Indeed, something in this direction will have to be undertaken on the receipt of news from the Northern Territory, now daily expected; and a few camels would greatly facilitate any overland party. I understand that some of Mr. Elder's herd would be available for this purpose, if required by the Government.

In conclusion, I think that every one who desires that the English race may rapidly be dispersed over, and may strongly grasp, the whole of this great country, over so much of which hot and dry and unaccustomed climates prevail, must feel satisfaction in the thought that Mr. Elder's experiment of introducing the camel into South Australia has, on the whole, proved so successful, and that it has been made upon a scale which promises, within the term of a few years, to make the camel as a beast of burden available for the use of the poorest settler in the most distant and most desolate of our scrubs and deserts. In speaking of this success, however, I do not refer to financial results. These are at present *in nubibus*. Under favourable circumstances it must be many years before there can be any adequate return for the large and continued outlay involved in the adventure.

SUBJECT—"THE USE AND PROPERTIES OF PLANTS."

NO. II.

Trusting that my former papers on Botany have not proved uninteresting to you, I now venture some further observations.

The next family of plants I wish to introduce to your notice is that of Palms (*Palmaceae*), which the immortal Humboldt has called the most interesting in the vegetable kingdom, the most lofty, noble, and majestic of all vegetable forms—that to which the prize of beauty has been assigned by the concurrent voice of nations in all ages.

The impression of these noble trees, on which nature has lavished such a variety in form, and which I viewed during my exploring tours in Guiana and Brazil, have impressed themselves with indelible character upon my mind, which is the more powerfully awakened since comparing our own trees with the magnificent Palms.

Professor Martius the famous Brazilian traveller, calls the Palms the noble offsprings of "Telus and Phoebus." They are natives of those happy countries, where the rays of the sun are ever beaming. In receding from the equator, and approaching the temperate zones, Palms diminish in height and beauty.

According to Humboldt, the indigenous vegetation of Europe only comprise a single representative of this form of plants.

During the great Linnaeus' time, only 15 spec. were then described; and at the present time more than 800 spec. are known.

The value of this family to mankind is boundless. Humboldt remarks:—Wine, oil, wax, flour, sugar, salt, thread, cordage, utensils, weapons, clothes, and habitation are their produce.

It would lengthen this paper, and perhaps tire your patience too much, should I venture to describe to you the properties of the different species of this family, as nearly every one has been lavished by nature with one or the other gift useful to mankind, and I will only mention the most important.

I will begin with my favourite, the South American Mauritia or Ita Palm (*Mauritia flexuosa*).

The earliest, as well as the modern travellers in Brazil and Guiana, as the Jesuit Grimilla and Gill, Hartsink, Aublet, Humboldt and Martius, all give the same enthusiastic description of this magnificent Palm. Where I met this Palm, during my travels from the beginning to the end, single or in groups, my eyes rested with the same delight on them, which nature seems to have favoured with every beauty.

The advantages and value to the natives of the Mauritia is so great that they call it "the Tree of Life." The fruits yield their food, drink, oil; the stem—houses, arms, utensils, flour, and wine; the leaves—cordage, the covering for their houses, and sandals for their feet. If there were an inclination amongst the South American Indians to worship idols, no doubt the Mauritia Palm, which offers them every necessary of the common life, would be the object of their worship.

The juice contains a great quantity of saccharine matter; and the experiments which have been made of extracting the sugar have shown a much more favourable result than that of the juice of the sugar maple. The juice of the flower-stalk is

still more delicious than that of the trunk, and resembles, when prepared by the Indians, similar to champagne. With what reluctance did I consent to the sacrifice of such a noble tree, only to quench our thirst with its fluid—only the sheerest necessity could induce me to do it. To extract quickly the sap from the tree, the Indians, after having filled it and cut out of the crown, raise it on the end of the stem, two or three feet above the ground, place dry wood underneath, and set fire to it, when the juice trickles quickly out on the end of the stem, which still rests on the ground.

The next Palm which I will mention is the Sago Palm, of the Moluscus (*Sagus laevis*). The finest sago is prepared from this species. A good many other kinds also yield sago, but not of such good quality. The stem is filled within with an enormous volume of a spongy, medullary matter or pith, like that of alder. This pith forms the edible sarina or sago, which, not alone, forms the bread of the inhabitants of the Molusca Islands, also so much used in Europe. The mass of nutritive matter afforded by one tree is enormous; it is said, to yield 600 to 800 pounds of sago is not unusual.

I call your attention to the various products of the Cocos Palm, or the "Staff of Life," as the tree is called by the natives. Bertolacci states that a full grown, healthy tree in Ceylon, will yield fifty to sixty nuts; Humboldt quotes the produce of South America, as averaging per tree, one hundred nuts annually; but, independent of the nuts, there are other various valuable products of the Coconut tree. I will only mention the, in India, so well known fermented liquor of the East, "taddy." According to E. Porter, it is drawn during six or eight months of the year. The tree, after that, being left to recover its strength through the dry season. At the end of the fifth or sixth month from the first appearance of a bud or flower-stalk, on a vigorous tree, it is in a fit state for extracting this liquor. If tapped at too early a period the tree soon becomes exhausted. Naturally, the flower spathe, subjected to the tapping of toddy, cannot produce fruits. From the toddy the best arrack is distilled in the East, in the same manner as brandy is obtained from wine.

From the fibrous husk, or outer shell of the nut, a cordage is manufactured, which equals the hemp in strength, is too well known to need description; also, that the oil expressed from the nuts has been long employed in the East, and its value is, in the present day, becoming better known and valued in Europe, of which now enormous quantities are consumed.

It seems that in Germany still more use is made of the coconut oil than in England. I believe it is not generally known, that all the ships of Messrs. Godeffroy & Co., from Hamburg, which arrive, not alone, in this part of the neighbouring colonies with passengers and goods, return to one of the South Sea Islands, the name of which has escaped my memory, where this firm has a large factory to collect, from the surrounding islands, coconuts, which, to economise space in loading, the nuts are cut, with their shell, into small pieces by steam-power, and with such the vessel is loaded, and, strange to say, it is found that the cargo does not become heated or mouldy by this system of packing.

According to Lindley, the Palm (*Saguerus saccharifer*), is the most important of this order in the Islands of the Indian Archipelago; the Molucas and Philippines, where it is of the greatest value on account of its saccharine secretions. This juice is obtained continually from the spadixes in large quantities, by wounding them while on the tree. It yields, by fermentation, an intoxicating beverage; and when boiled, a kind of sugar. When the trees are exhausted by the constantly draining of this fluid, sago of a good quality is obtained from the trunk—as much as 150 and 200lbs. from a single tree. Its timber is fit for building; and the leaf stalks yield, annually, from 4 to 7lbs. of a strong black fibre, resembling horsehair, and used in the manufacture of cables and ropes. Finally, there is, at the base of the leaves, a fine frothy material, much employed in caulking ships and stuffing for mattresses.

It is said that the fruit of saguerus is of that nature, exciting severe inflammation in the mouth of those who chew it. It was the basis of the infernal water, which the Molluscians used in their wars to pour over their enemies. Nevertheless, the unripe albumen forms a beautiful kind of sweetmeat, which the Chinese drink with their tea. It is prepared by soaking in wine-water, and boiled in refined sugar.

Who of you have not eaten and delighted, when a boy, in the fruits of the Date Palm (*Phoenix dactylifera*), which forms the important food to the tribes of the desert? It is one of the most fruitful trees. A single spathe or flower-stalk of the Date Palm contains, according to Lindley, 12,000 male flowers, and is only surpassed in its fruitfulness, by three other palm kinds, namely:—The *Alfonsonia Amygdalina* has been said to have 207,000 in a spathe, or, 600,000 upon a single tree, while the bunch of the *seje* Palm, of the Orinoco, bears 8,000 fruits.

The Wax Palm of Humboldt (*Ceroxylon andicola*), has its trunk covered by a coating of wax, which exudes from the space between the insertion of the leaves. It is, according to Vauquelin, a concrete inflammable substance, consisting of one-third wax and two-thirds resin.

I assume you all have heard of the Cabbage Palm (*Areca oleracea*), whose huge terminal bud is considered, in South America and the West Indies, as a most delicious cabbage, which, in flavour, surpasses anything of this kind. Unfortunately, to obtain a few dishes of this luxury, the life of such a noble tree must be sacrificed, as it must be cut down.

I come now to a remarkable palm, the well known Betel nut, the fruit of the *Areca Catechu*, remarkable for its narcotic or intoxicating power. What the tobacco is to the Europeans and North American Indians, is the chewing of the Betel nut to the Asiatic natives. After bloom, they would rather forego their bread and drink than their favourite areca. There is no man, woman, or child over ten years of age, in Siam, who does not indulge in the passion of chewing the Betel nut. A Siamese would not miss so much his "Staff of Life," the rice, as his Betel. It is calculated that the average consumption of a Siamese is 12 nuts per day; and the average yield of nuts of a tree, are 800 to 1000: whole shiploads of which are annually exported from Sumatra, Malacca, Siam, and Cochin China.

After Lindley, it has been thought doubtful, whether the intoxicating effect of the Betel nut is not owing to the piperleaf in which it is wrapped when eaten, rather than to any special property of its own.

It would take still hours, did I venture to tell you of all the economical purposes to which the products of the different palms are applied. But I cannot leave this interesting tribe, "the princes of the vegetable world," without mentioning the graceful Truly Palm (*Manicaria saccifera*), of British Guiana. Not alone is the fruit used for food by the Indians, but its gigantic leaves are employed, as the best thatch, by the Indians, as well as the colonists, and so form a great and important article of commerce in the colony; but it furnishes also the Indians with clothes. Underneath the outer bark of the stem is a layer of a fibrous matter, similar to coarse canvass, which is easily stripped off the stem after beating it with a stick. The Indians cut it to the required lengths, cut the armholes, and then sew the sleeves on, and the shirt is ready for use.

What a contrast, in every regard, in form and habit, with the foregoing family and the family which I will now introduce to your notice, namely, "the Indian figs" (*Cactaceae*), but alike interesting, from the remarkable formation of their stem, as well as the brilliant colour of the flowers. They cannot fail to become objects of interest, especially to the botanist, and in fact, generally to every educated mind. When contemplating this family of plants we cannot help thinking that nature created them in one of her frolicsome moods. There is hardly anything in the vegetable physiognomy of South America, which, during my travel, made so singular and indelible an impression on my mind as the sight of an arid plain or rocks, covered with cacti with gigantic and grotesque forms. Everything here is wonderful! With the exception of the genus *pereskia*, not one of the cactus tribe has real leaves. What we call leaves, with respect to cactus *alatus* and the Indian fig, are nothing else but attenuated and flattened stems. But all cacti are marked by a fleshy stem, covered by a green, leatherlike epidermis; and where the leaves ought to have their place, nature has supplanted them by hairs, spikes, and thorns, whose different constructions and arrangements materially helps to identify each species. Some stems are characterised by four or nine longitudinal ribs, other species present the striking likeness of a giant candelabra, 30 or 40 feet high; then again, some look like a hedgehog, bristling with sharp thorns; others, formed like the body of a snake, creep like climbers up the trees, and hang down their branches like a stockrider's whip.

According to Humboldt, some of the so called meloncactus he found three or four feet high and seven feet in circumference: some weighing from 200 to 2,000 lbs.; while again, the cactus nanus is so very small that being only slightly rooted in the sand it gets between the toes of the dogs.

Linne, the famous botanist, was only acquainted with about 12 species of this family; at the present time there are known more than 600.

Very few families of plants have such a small extension as the cacti tribe. America is the extensive station of the Indian figs, no species appearing to be natives of any other part of the world. It seems that after the discovery of America many spec. were introduced to other parts of the globe. According to Lindley, especially since the last century, some have extended themselves in a remark-

able manner into North America, Syria, Greece, and the whole of South Europe: even penetrating in Africa from the coast far into the interior of the country, and associating itself with the indigenous plants.

The remarkable distention of the cellular tissue, which gives nearly all the cactus plants such a singular appearance, is caused by an extraordinary structure of the sap containing vessels, which are shaped like lamina, instead of being constructed in the usual shape of spirals and rings.

Hot, dry, rocky, and sandy places, where no other vegetation could exist, are favourite situations of the cacti; for which they are peculiarly adapted, in consequence of the imperfect evaporating pores of their skin. With truth has the botanical traveller, Bernhardt de St. Pierre, applied the term "the vegetable fountains of the desert" to them, as the plants contain a great quantity of a refreshing acidulous juice of an agreeable taste, which is especially contained in the so-called meloncactus. With what delight did we hail such plants, when travelling over the Savannas, in South America, to quench our tantalizing thirst.

The wild mules and horses of the Llanos know also the properties of these plants. During the dry season, when all animal life has left the Pampas, the wild mules and horses, when suffering from thirst, only are seen roaming over the endless deserts in search of the cacti, to quench their thirst, but first, carefully with their forefeet, they strip the cactus of their dangerous spines; and, after moving these obstacles, they seek the cooling juice.

I will now call your attention to the manifold fruits which some cactus species contribute to the household of nature—many of the fruits being refreshing and agreeable, in others, insipid. For instance, in Mexico and the West Indies, the opuntia, commonly called the Indian fig, furnishes the inhabitants of the countries with a delicious fruit; and a similar sort of opuntia is planted to form good hedges. Its bruised stem yielding a juice used for cooling fermentation for ill-conditioned ulcers; its fruit, boiled to jam, is useful in cough mixtures. According to Lindley, the fruit of opuntia vulgaris has the property of turning red the urine of those who eat it.

But as it is not my intention to treat you to a scientific description of the cacti. I would rather call your attention to the most useful quality of the cactus tribe: all the other shrink into insignificance, when we consider that several species are the feeding plants, whereupon the Cochineal insects (*Coccus cacti*) are raised. I am sure everyone of us is acquainted with the cochineal. This little insect, similar to those sometimes infecting our storehouse plants, live only on a species of cacti, called "Opuntia tuna." The splendid and so valuable colouring matter, called "carmine," so much used in dyeing, is produced by these insects; and with reference to this Mexico, as well as several of the West Indian Islands, export large quantities every year. The trade is likewise supplied with the same article from Brazil and East India; but Mexico supplies the largest quantity, and, at the same time, the finest quality.

Till the year 1725 the breeding of the cochineal was entirely confined to Mexico, and the Government, with the strictest care, kept it a secret; and till then, it was generally believed in Europe that the cochineal was not an insect, but a kind of seed. In the year 1785 Thierre de Menonville, a

Frenchman, with the greatest danger of his life, brought a few living insects to French Domingo, where they soon were climatised. During 1827, the insect was, by Berthelot, introduced to the Canary Islands, and lately, with the best result, in Corsica and Spain.

Now, if the insect thrives well in Spain and Corsica, why should it not thrive in South Australia? Before going further into the subject of introducing the cochineal as an article of commerce to our adopted country, I will bring a few facts of the immense value of the insect.

According to Humboldt, the export of cochineal alone, of the Mexican Province Oaxaca, amounted to three-fourths of a million dollars. Now, assuming that one pound of cochineal is worth 10 dollars, and that 70,000 of these insects make one pound, this province alone, must rear an immense quantity of Cochineal insects. Particularly in the Mexican Provinces, Oaxaca, Tlascala, and Guanaxuato, the insects are bred. For this purpose large haciendas or farms, called "nopaderos," are established, where the Opuntia "nopal" (*Opuntia tuna*), is planted by acres. But in the West Indies and in Brazil, another species of cacti is used, namely, the Opuntia coccinellifera. These plantations very often have to be renewed, because, as the insects derive all their nourishment from the plants, it may be easily imagined that a number of these occupants, by this constant sucking, must inevitably exhaust and destroy them.

According to Professor Scheiden, the cochineal of commerce is exported in two different samples, namely, as "Grana fina," and "Grana sylvestre." The first is said to possess more colouring matter, and a richer colour; besides, the insects producing it are known by a fine layer of whitish dust covering them; whereas the second sort is covered by a flaky-like substance. But at the present time, it is still doubtful whether these are two distinct species of Cochineal insects, or the difference is only a consequence produced by different methods of cultivation and change of the feeding plant. When the insects are fully developed, the Mexicans use the tail of a squirrel to brush them gently from the plants into baskets, kill them, either by steam or exposure to the heat of the sun, and export them.

The splendid dye called "carmine," so well known everywhere, is obtained by placing the insects in spirits of wine, and treating them afterwards with alum.

Before closing my paper I will mention a few words about the introduction of the Cochineal insect in this colony. Not that I am sanguine of its success.

Both kinds of the Cochineal, Opuntia tuna and Cochinealifera, which I introduced by raising from seed, grow luxuriant in the open borders at the garden, without having bestowed the slightest care on them. This gives the fact that the plant will thrive in Australia. The second and most important question would be, how to introduce the insect. This naturally, could only be done on living plants, in so-called Wardian cases.

I understood that Sir George Grey, when Governor in New Zealand, introduced the Cochineal insect there; but what became of them I have no information. I was also told that His Excellency sent some insects to the Melbourne Botanic Garden but they were lost. It is my intention to communicate with the secretary of the Acclimatisation Society in Auckland, in regard to the insects. Should they be still alive, it would be easy to introduce them here.

PAPER READ BY MR. B. H. BABPAGE, ON TUESDAY, DECEMBER 21, 1869.

SUBJECT—"THE CURRENTS OF THE AIR AND THE OCEAN."

NO. III.

Since writing my last paper, my friend Mr. Todd has kindly lent me the "Handy Book of Meteorology," second edition, 1868, by Alex. Buchan, secretary to the Scottish Meteorological Society, from which I find that new views are entertained by some European meteorologists, respecting the cause of the movement of the air in the cyclones of the tropics, and in the rotatory storms of the temperate regions. These views are embodied in the observations of Buchan: "that all winds are directly caused by differences of atmospheric pressure, and, consequently, all winds arise from changes occurring either in the temperature or in the humidity of the air." Buchan explains the origin of the trade winds exactly in the same way which I detailed in my first paper, such being the generally received explanation of it. With respect, however, to the cause of the monsoons, there is a difference of opinion amongst meteorologists. I will therefore first give you the recent views upon this subject, as laid down by Buchan, and then Professor Dove's views, taking the monsoons of the Indian Ocean as an example.

Buchan gives two plates of isobarometric lines, showing the mean atmospheric pressure of the globe in July and in January. On examining these plates it will be seen that, in July, there is in the interior of Asia a large area covering 20° of latitude and 40° of longitude, in which there is a low atmospheric pressure, the barometer standing at 29.5 inches; whilst to the south of the equator, as far as latitude 40° south, the mean pressure is high, being 30 to 30.1 inches. In consequence of this difference of pressure, the air from the south of the equator flows over the Indian Ocean on its way towards the region of low pressure in the interior of Asia; but, as in its progress northwards it is continually flowing into places having a greater velocity of rotation than itself, it becomes, after crossing the equator, a south-west wind, and takes the name of the south-west monsoon of the Indian Ocean. Buchan gives a table of the direction of the winds in July, derived from the mean of observations extending over from two to ten years, at nine places in Asia, upon different sides of this region of least pressure, and shows that the "particular course taken by the winds is a flowing in towards the centre of least pressure in an in-moving spiral course;" and he states that this accords with Dr. Buys Ballot's "Law of the Winds." Buchan says that, according to this distinguished meteorologist, if a line be drawn in the direction of the wind, and another from the place of observation to that of least pressure, the angle is generally from 60° to 80°. The angle is frequently as small as 45°, especially where the winds become lighter on approaching the central space of least pressure, and, on rare and peculiar occasions, it exceeds 80°. The reason why the wind takes this direction may best be shown by an example, and recurring to the case of the region of least pressure in Central Asia, we shall see that the air to the south of it would start in a north direction; and, as stated above, owing to the effect of the rotation of the earth, would finally become a south-west wind, and move towards the north-east, or towards the right-hand side of the centre of least pressure. Again, the air on the north side moving into places having a less velocity of rotation, on its progress south, would acquire a westerly direction, and would finally move towards the south-west, or, as before,

to the right-hand of the region of least pressure: thus the air to the north and south of the region of least pressure would pour in upon it at an angle, and the result would be to make these currents rotate around the central space, in the contrary direction to the hands of a watch; but as the air from all sides would be pressing in towards this region, and be more or less affected by the rotation of the earth, and the air at the place would have a tendency to rise, being lighter than the surrounding air, the wind would blow round in, what Redfield and Buchan call, incurring spirals. Buchan says that he has observed this peculiarity in all the European storms which he has examined. It must, however, require a great number of observations to prove that this movement actually took place in any one storm on land, as the direction of the wind is there so much affected by local causes that it becomes difficult to ascertain the general law. On examining the chart in Buchan's work of the direction of the winds during the storm which passed over England on the 2nd November, 1863, it will be observed how much the winds on land have evidently been influenced by local causes, the direction in some places being even directly opposite to that required by the theory. It will be remembered that, in my previous paper, I showed, from theoretic considerations, that the form of rotatory storms should be elliptic and not circular; and I find that Mr. Buchan's observations prove that such is really the case with them. Buchan supposes that all storms, whether cyclones, typhoons, hurricanes, &c., are caused by the air rushing in towards the centres of least pressure, in the same way as has been described above in the case of Central Asia; but it seems to me that he is wrong in this supposition; nor can I agree in his statement that it is proved that every storm is vorticeous, or blowing in towards a centre in incurring spirals; and, therefore, that "this must be accepted as the law, in accordance with which the course of the wind in storms is regulated." My own opinion is that storms are of two kinds; one, the ordinary storm of the temperate regions, which, no doubt, does take its origin and rotate in a vorticeous spiral, as represented by Buchan; but the other, of which the cyclone of the West Indies may be taken as a type, is, as far as I can judge from the facts related, of a different character and origin. With regard to the exact direction of the wind—whether it is incurring, or blows round in ellipses, or other cyclonic curves—it must be remembered that the general direction can only be ascertained correctly at sea where there are no local disturbances; and that it is extremely difficult to determine this point on board a vessel in the midst of a hurricane, which may or may not be drifting at the same time with a strong surface storm-current, thus affecting the apparent direction of the wind. The number of true synchronous observations of any one cyclone can be but few, as it seldom happens that more than one or two vessels are involved in it at the same time; and it is rare indeed that their actual position can be determined, except by estimation, as no observations can be taken during a hurricane; and besides, for the proving of vorticeous motion of the air it requires the real position of the centre of a storm to be known also, so that a person may well be pardoned for doubting whether this vorticeous motion has been fully established by observation. There are some considerations which are decidedly

opposed to the idea that a cyclone is caused by the air blowing in towards a centre of low pressure; and, therefore, notwithstanding the great authorities whom Buchan quotes as having adopted the view of the "spirally in-moving cause of the winds in storms," including Buys Ballot, Sir J. Herschel, Maury, &c., I confess that I cannot as yet agree in their views, and am rather inclined, in this matter, to agree with those of Professor Dove. Indeed, Buchan himself, after laying down the law as unassailable by argument, says, "the part of the track of the West Indian hurricanes, after turning to the north-east, is in accordance with this theory; but how account for the first part of their course, which is at right angles to the prevailing trade winds of that region?" How indeed! If the theory does not account for the facts, it can scarcely be so "unassailable" as Buchan considers.

With regard to these cyclones the question arises, is the low pressure at their centre the cause or the effect? If it is, as Buchan maintains, the cause why the air rushes in and produces a rotatory storm, then the local excess of heat or sudden condensation of aqueous vapour, or whatever it may be, which produces this low pressure, must itself move along in the parabolic course taken by the cyclones—a course which has been distinctly traced from the West Indian Islands to the North Atlantic—or past the equatorial belt and far into the temperate zone—a distance of four or five thousand miles. No known cause can be assigned for this movement. If, on the contrary, the low pressure is the effect of the revolving motion of a body of air saturated with aqueous vapours, or with water in a very minutely divided state, then it only becomes necessary to explain the movement of this body of air, as I have attempted to do in my previous paper, and the whole thing becomes intelligible. If a cyclone is caused by the surrounding air rushing in towards a centre of low pressure, the trade wind should be altered in its course and drawn towards and follow the cyclone. But no such effect takes place: the trades appear to follow their usual course up to the path of the cyclone, and before it arrives and as soon as it has passed, to blow across its track. West Indian cyclones are first met with in about 15° of north latitude, where the difference between the diurnal circles being but small, the different velocities of rotation of the earth derived from them would but slightly effect the direction of the wind if it were rushing in towards a centre; and we ought to find, upon this supposition, the wind blowing violently towards that centre, and it would only be as we approach the vortex that a spiral movement would become evident. I do not, however, find any record of such an in-blowing having been observed. On the contrary, the outskirts of these storms, wherever met with, have the regular cyclonic movement which characterizes the wind around the centre. Upon Buchan's theory, the air should begin gradually to draw in on every side, increasing in its centripetal movement as it approached the centre, a motion which is very well shown in his chart of the storm of November, 1863, where the wind in the outskirts of the storm is represented as blowing nearly towards the centre, and where it is not, until nearing the centre, that the spiral direction of the wind shows itself.

Again, as the wind approached the centre and began to rise up in the air, its force below should diminish gradually, or as quoted above, the winds

become lighter on approaching the central space of least pressure. But the observations made during cyclones do not confirm these deductions from the indraught theory, for not only is a cyclone distinctly observed at a distance as having a defined dark wall of fog or cloud, but the moment a vessel is involved in it, the wind is found to be of the force of a violent gale, and to have the regular cyclonic movement; and, besides, on entering the calm centre an immediate lull is observed, the line of demarcation appearing well defined instead of their being a gradual cessation of the violence of the hurricane; and, moreover, the veerings of the wind in the outer parts of the cyclone agree with a cyclonic movement, but are contrary to the direction that would be due to an indraught.

Sir John Herschel in the Admiralty Manual says, "Mr. Redfield has shown that on some occasions storms have been preceded by an unusual pressure of the atmosphere; the barometer has stood remarkably high, and it has hence been inferred that there has existed around the gale an accumulation of air forming a margin." This is easily explained by the cyclonic theory, but would be contrary to what one would expect to find from an indraught.

Again, it may be asked how the lull which takes place after the outer part or margin of the cyclonic storm is past can be explained by the indraught theory? I have endeavoured in my preceding paper to show how it may be accounted for by the cyclonic one.

There is one other point which requires notice in the theory of cyclones, and that is the great fall of the barometer on approaching their centre. Buchan says that "Professor Loomis has shown that any observed velocity of the wind round the centre is altogether inadequate, on the principle of centrifugal force, to bring about the low pressure at the centre;" and that he has calculated the depression due to this cause at little more than 0.02 inches of mercury, on the supposition that the mean velocity of rotation of a portion of the atmosphere 300 miles in diameter was seventy miles an hour. In order to judge of this calculation it would be necessary to know a little more respecting the data assumed by the Professor, since if he took the height of the revolving air at half a mile, it is clear that for each additional half mile there would be another 0.02 inch of depression. Again it would be incorrect to take a mean velocity, seeing that the effect of the centrifugal force does not vary in the simple ratio of the velocities. It is not, however, to the mere mechanical effect of the centrifugal force that we must look for the cause of the great barometrical depression in the interior of cyclones, but to the chemical effect of the condensation of the enormous quantity of aqueous vapour which is so constant an accompanying phenomenon of cyclones. The deluges of rain which take place outside the limits of the calm centres of cyclones must set free a large amount of caloric, whose heating action both by expanding the air and by enabling it to retain a larger proportion of vapour, combined with the effect of the centrifugal force, may be readily shown to account for the low barometrical pressure in the centre.

Professor Dove takes the view that the movement of cyclones is rotatory, and as I have pointed out in my former paper, ascribes it to the conflicts of opposite currents; and he too considers the low barometrical pressure as a secondary effect, and not the original cause of cyclones. He brings forward as a proof of this Heskiaer's observation that, during a hurricane at St. Thomas's, at each gust the level of the barometer sank 0.20 of an inch, but returned to its former height when the gust was over.

The greatest difficulty in the centrifugal theory is, as Buchan himself admits, to account for the area of low pressure taking the path described by the West Indian and Mauritius hurricanes. In the case of the European storms of large area given by him, there does not seem to be any difficulty of this kind; for suppose the equatorial current over a large tract of country to have reached the surface, and to be moving in a polar direction, if some local circumstance causes a sudden condensation of vapour or heating of the air, and thus deranges the barometrical equilibrium, the general current would continue its polar course, carrying along with it in its progress the area of least pressure with its attendant isobarometrical

curves; thus the storm caused by it would advance northwards with the general progress of the current; and in proportion as the rush of air restored the equilibrium it would die out. Thus, the record of it would show a distinct onward track during its continuation. The case is very different with the cyclones of the tropical regions, which do not advance with the prevailing currents, but often travel at right angles to them, if not actually in an opposite direction, and their progress cannot be accounted for by the same law.

Besides the trade winds, which blow constantly in one direction, there are other winds called monsoons, which change their direction periodically, blowing in one direction for a portion of the year, and in the opposite direction during the remainder of the year. The monsoons which have been the most carefully observed, and therefore about which we know the most, are those of the Indian and China seas.

In treating of the monsoons, I purport following the same plan which I did with the cyclones, namely, first to give a slight sketch of their nature and localities, and then to explain the theories which have been proposed to account for them.

All the monsoons have one feature in common, viz.: that the general time of their change depends upon the time when the sun crosses the equator, the time being a little earlier or a little later, dependent on local causes.

The monsoons in the Arabian Sea blow from the north-east from November to March, being the time when the sun is to the south of the equator; they begin to fail towards March and are succeeded by alternate land and sea breezes, and in April S.W. monsoons commence and blow until October, during which time the sun is to the north of the equator. At the time of the passage of the equator, that is the equinox, the winds are variable and the weather usually stormy. The N.E. monsoon brings rain to the eastern coast of Africa, but is not itself a rainy wind; on the other hand the S.W. monsoon is accompanied by dark rainy weather, and brings a great quantity of rain to the western coast of India, the amount of rain diminishing as you go northwards until the coast of Beloochistan receives but a few showers.

In the Bay of Bengal the monsoons are not so regular, either in their times of commencement or in their direction. The north-east monsoon there does not set in until December, when it blows from N.N.E. and E.N.E., changing sometime to the S.E. This monsoon is preceded by squalls and storms, which bring rain to the south-east coasts of Hindoostan. The south-east monsoon also varies in its direction, blowing frequently from the south, and even south east, near the mouth of the Ganges. This monsoon brings rain to the northern and eastern coasts of the Bay of Bengal, where, as in the coasts of the Arabian Sea, the rainfall diminishes on going inland. A glance at the map will at once show the reason why these monsoons bring rain to different places at different seasons. Both monsoons sweep over a sea, from which, owing to its temperature, the evaporation is considerable; thus they collect a large amount of moisture, which they deposit as rain when they reach the coast; wherever, therefore, the monsoon has blown over a long reach of ocean before it impinges upon the land, we may expect to find a large amount of rain; and as the ocean path becomes shorter, the amount of rain diminishes. Of course, the farther it advances inland, as there is no longer an ocean surface to feed it, the less rain it has to give up, and it soon becomes a dry rainless wind.

The monsoons in the China seas are still more irregular than those of the Bay of Bengal. The general direction of the winds in these seas are S.S.E. and N.N.W., and they bring rain whenever they reach the land after blowing across any considerable surface of water, in the same way that the monsoons do in the Arabian Sea and Bay of Bengal.

Upon the southern side of the equator, the monsoons in the Java Sea blow from the west when the sun is in the south; and from the east when the sun is in the north; but on the south coast of Borneo the monsoons appear to be S.W. and S.E. Amongst the islands to the north of the Australian east and west monsoons prevail, but these monsoons are not so constant in their direction as those in the Indian and China seas, turning occasionally to the north-west and south-east. Dove gives several tables of the directions

and intensities of the wind in the Northern and Southern Indian Oceans; and he observes from them that the minimum intensity of motion is in the vicinity of the equator, and that this fact is more marked to the south than to the north of the line. These tables show that there is in this ocean no zone of calms like there is in the Atlantic; but that in place of it there is a constant current of air during the summer months, the direction of which changes on crossing the equator from south-east to south-west. In Japan the monsoons vary from N.N.E. to W.N.W. and from S. to S.W. according to the seasons.

Where the trade winds blow in the vicinity of land their direction is generally modified. When a coast line is north and south, the trade wind is drawn in towards the land by day owing to its warm temperature and its direction altered, but it is not affected at night, and regains its original direction, and when this is the case the winds are called coast winds. Again, at east and west coast line also modifies the trade wind, and gives rise to local monsoons, but as my object is to give a general view of the air currents, it will not be necessary to dwell upon the details of these purely local winds.

We have now to consider the various theories advanced as the cause of the monsoons. In treating of the cause of storms, I have already explained how, in accordance with the law enunciated by Buchan and other recent meteorologists, "that the air flows to the centres of least pressure;" the S.W. monsoon is generated in the South of Asia and in the North Indian Ocean, during the Northern summer. Buchan gives a chart of the isobarometrical lines of the globe in January, which shows that there was then in Central Asia a high barometrical pressure, whilst at the same time the pressure is low at, and to the North of, the equator, and consequently at that season there would be in the Northern Indian Ocean a flow of air from Asia towards the equator, which owing to the rotation of the earth would take the same direction as the trades, namely N. E.; thus in summer a S. W. and in winter a N. E. monsoon would be established.

Dove proceeds in the following way to establish the cause that originates the monsoons, and in the first instance in order to be able to understand the meteorological observations, he makes an analysis of the barometrical pressure. He observes "that the barometrical column consists of two portions, one of which is due to the weight of the dry air, and the other to that of the aqueous vapour." If the temperature is increased the dry air must expand and become lighter, but at the same time its capacity for holding vapour and the amount of evaporation is also increased, and with it the elastic force of the vapour contained in the air—the result is that in a given space there is less air and more vapour, but the air is expanded and becomes lighter, whilst the vapour is heated and by its increased elasticity presses more heavily on the barometrical column. For example vapour at 60° raises the mercury about half an inch, at 56° 1 inch, at 50° 1.43 inch, and at 103° 2 inches—thus heat may be said to make the air lighter and the vapour heavier, and Dove remarks "until we can ascertain the quantitative relation of both these variations which take place simultaneously but in opposite directions, we are unable to determine whether the total pressure is increased or diminished by a rise in temperature, or whether at one period the total variation is not in one direction and in another in that which is opposite." In the absence of all the necessary data, Dove has compiled several tables giving the pressure of the dry air for each month at a number of places within the influence of the northern monsoon of the Indian Ocean, obtained by deducting the tension of aqueous vapour from the observed heights of the barometer. A comparison of these tables with that of the total barometrical pressure shows that throughout the whole of Asia the fluctuations of the pressure of dry air follow very closely those of the barometer: so that for practical purposes, in that region at least, as regards the rarefaction of the air affecting the movements of the atmosphere, we may be guided by barometrical observations only, without eliminating the effect of aqueous vapour. The fact of a place being either surrounded by water, or in the neighbourhood of water, or being altogether inland, would make a difference in the effect caused by a rise of temperature in that part of the barometrical pressure which

due to aqueous vapour: and calculation shows that the difference between the mean winter and summer heights of the barometer, other things being equal, should be greater over the sea where the air is saturated with moisture, than over the land upon the same isothermal lines where the amount of moisture is limited. But the variation between summer and winter temperature being much greater in the interior of extensive colonies such as North America, Europe, and Asia, than on the coast or at sea, this difference is entirely concealed by the greater differences occasioned by the extreme variations of temperature. Hence, notwithstanding this, Kaemtz's remark stands good for these continents, that "further observations will prove that in equal latitudes the differences between the pressure of dry air in summer and winter are greater in the interior of continents than on the sea coast."

If the temperature of a place where the atmosphere is saturated with vapour be lowered instead of raised, there would be no difference in the height to which the barometer would be raised, whether the air was in contact with water or not, since air at a lower temperature holds less water in the state of vapour than air at a higher one; so that whether on sea or land, there would be a superabundance of vapour, and the excess beyond what was necessary for saturating the air would be condensed.

Dove having proved by his tables that the total barometrical variation may be used as a measure of the variation of pressure in dry air, shows by an extensive examination of barometrical observation, that there is in the summer time an area of maximum rarefaction in Central Asia extending from Calcutta in the south to Lake Baikal in the north, and from the Sea of Aral on the west to Pekina on the east.

Surrounding this area of maximum rarefaction is a much larger one, in which the air is still highly rarified as compared with its mean state, which includes the greater part of Asia and a considerable part of the south-east of Europe, the north of Africa, Egypt, and Abyssinia, on which he remarks "if we remember that all the great deserts are included within the area, we are referred so directly to the action of the aqueous vapours that we are justified in expecting to find the grounds of this phenomenon therein." The phenomenon to which he refers being that the areas of maximum temperature, and maximum rarefaction do not agree, and that as the point of minimum atmospheric pressure lies to the northward of that of maximum temperature, the current of air from the southward is attracted not only to this latter point but beyond it.

Dove attributes to the effect of aqueous vapour the fact that this region is so far north of that of maximum temperature, and says that "the monsoon is nowise a phenomenon produced by the attraction of air from a colder towards a warmer point, as is still maintained by modern writers who follow in the steps of the old text books."

Let us examine the barometric and thermometric conditions of the northern and southern limits of the area of maximum rarefaction pointed out by Dove, and take Barnaul and Irkutsk on the north, and Calcutta on the south as being near the limits. Mahlman's table of mean temperatures quoted in Walker's translation of Kaemtz's Meteorology gives -1° Fahrenheit for the winter temperature of Irkutsk, (that of Barnaul is not given, but judging from the tension of vapour at the two places, the temperature must be nearly the same), whilst the summer temperature is 61° . At Calcutta the temperatures are respectively in winter 68° and in summer 83° . Dove's tables give the barometrical pressure at the two places and we get the following remarkable results:—

AT CALCUTTA.

	Mean of three summer months.	Mean of three winter months.	Mean of year.
	inches.	inches.	inches.
Dry Air	28.57	29.50	28.98
Aqueous Vapor ...	0.96	0.55	0.79
Total Pressure ...	29.53	30.05	29.77†
Rarefaction	-0.262	$+0.295$	
Temperature	83°	68°	75.5

† 29.713 by tables.

AT IRKUTSK OR BARNAOUL.

	Mean of three winter months.	Mean of three summer months.	Mean of year.
	inches.	inches.	inches.
Dry Air	29.78	28.88	29.39
Aqueous Vapor ...	.75	.38	.19
Total Pressure ...	29.83	29.26	29.58
Rarefaction	$+0.249$	-0.324	
Temperature	-1°	$+58^{\circ}$	$+32^{\circ}$

These barometrical heights appear to be already corrected for elevation, although I can find no mention made of this in Dove's work (Scott's translation, 1862), as Irkutsk is from 1,200 to 1,300 feet above the sea, and if the correction for the barometer (about $1\frac{1}{2}$ inches) were deducted, it would leave the height of the barometer at Barnaul and Irkutsk much too low. We have seen that Dove's area of rarefaction extends from Calcutta to Barnaul and Irkutsk, notwithstanding the great difference between the atmospheric pressures in the two places, and this apparent discrepancy naturally leads us to a closer examination of the principle upon which Dove proceeds in order to determine the area of rarefaction. The way by which he arrives at the pressure of dry air we have already seen; the rarefaction he measures by the difference in barometrical pressure between that of July and the mean of the whole year. Dove gives no explanation of the way in which rarefaction thus measured affects the winds, but I imagine the assumption is, that the mean pressure of the year shows what the atmospheric pressure would be if the air were in a state of equilibrium, and therefore tranquil, and consequently there must be a tendency where the pressure exceeds this mean for the air to flow off to places where pressure is below the mean. But whether this be so or not, although Dove has been at great pains to ascertain the variations from this mean, in his reasoning he neglects this point altogether; for instance, he says:—"We have seen that the trade winds set in from both sides to that parallel of latitude within the torrid zone at which the total pressure of the atmosphere is least," as explained above; but if

we examine Dove's tables, we shall find that the rarefaction is *very small*, almost a minimum in the equatorial belt, and would not have power enough to draw the air towards it for any distance. But, if disregarding the rarefaction altogether, we turn to Buchan's valuable isobarometric charts, we find that they show a low pressure at the equator, with a higher pressure in the North and South Atlantic, both in January and July as well as for the mean of the whole year, so that the air flows from the adjacent regions of higher pressure into that of lower pressure; as this difference continues more or less throughout the year, it explains the reason why in the Atlantic Ocean the trades are so steady throughout the year.

Dove's own explanation of the monsoons is that the S.E. trade wind crosses the equator towards the area of maximum rarefaction, and that the rotation of the earth on travelling northwards changes its direction and it becomes the S.W. monsoon, and that in the same way the N.E. trade wind on crossing the equator becomes the N.W. monsoon of the southern hemisphere, and a table given by him of the directions of the wind in the Indian Ocean from 10° south latitude to 25° north latitude shows very clearly that the S.E. monsoon *does* cross the equator, as Dove says, and becomes the S.W. monsoon.

The difference between the explanation of Dove and that of which Buchan is the most recent exponent, consists in this—that whereas Dove attributes the monsoons to the movement of air flowing towards a place where the pressure is below the average of the year, causing a rarefaction (not necessarily as regards the surrounding regions, but as compared with the pressure at the same place a few months back), Buchan, Buys Ballot, &c., attribute them to the movement of air from places having a high barometrical pressure to other places having a contemporaneous low one. In one sense it is an effort of the atmosphere to return to what is assumed to be its normal state of equilibrium, in the other to restore the equilibrium disturbed by existing differences of pressure.

The results to which the rarefaction theory, if I may so call it, would lead us, are well shown by the barometric and thermometric conditions of Calcutta and Barnaul given above. The rarefaction of Calcutta for the three summer months as given by Dove is 0.262 , and that of Barnaul 0.324 , so that the air at the two places should be nearly in equilibrium; but the barometric pressure of the three summer months is respectively—Calcutta 29.53, Barnaul 29.26, showing a difference of pressure sufficient to cause a considerable movement of air from the former to the latter place. A further examination of Dove's tables would show many other discrepancies between the rarefaction and the height of the barometer. At Nertchinsk for instance, which is geographically within Dove's area of maximum rarefaction, the amount of it for the month of July is only 0.221 , whilst the mean height of the barometer is only 27.78. Not only theoretical reasoning, but facts seem to me against Dove's views, and I am therefore led to the conclusion that the theory of the air flowing to the points of greatest pressure, as more particularly explained in Buchan's late work, is probably the true explanation of the general cause of the movement of the winds.

I have in this and the preceding papers endeavored to explain the origin and causes of the principal currents in the atmosphere; but there remains one subject most interesting to us, connected with the variable winds, which I purpose taking up before going into the ocean currents, as the subject of my next paper, namely:—"The Meteorology of our own Continent of Australia."

PAPER READ BY MR. T. S. REED, ON TUESDAY, MARCH 15, 1870.

SUBJECT—"THE IMPORTANCE OF SILK CULTURE AS A BRANCH OF COLONIAL INDUSTRY."

In any period of the history of a colony, it behoves each of its members to obtain something like an intelligent apprehension of causes that may tend towards its general advancement.

This is a duty which appears, amongst us, practically to have been somewhat neglected. Causes of depression have arisen, have passed by, have repeated themselves, and as yet have failed to suggest practical remedies that would operate effectually in a permanent removal of the pressure, and in bringing back the tide of prosperity, which appears to have been rapidly ebbing away.

Our position as a colony has been ably described by one of our fellow-colonists in a work published in 1864, as "a few people possessed of a very large estate, and with vast undeveloped resources." And it is undoubted that many—perhaps most—of these resources remain yet untried, and that these periods of stagnation spring from the very circumstance that our colonial industries are so limited in their number and extent, as to render us liable to constant alternations between excess and depression of labour, alike hurtful to the employer and employed.

Mainly, our channels for the employment of labour may be confined to two branches, the agricultural and the mining. Neither of these affords permanent, constant employment. A dry season is sufficient to put a sudden check upon the first, throwing considerable numbers out of employment; and at the best of seasons the agriculturist and the sheepfarmer act upon the labour market, appreciably only at certain periods of the year.

The mining and gold seeking are subject also to great fluctuations. In the last of these, anything short of a flowing and uniform success is sufficient to discourage a large number of the unwilling and the indolent. If this assertion were untrue, there would be hundreds more of our working-men at the diggings than there are; but precious things, of whatever kind they be, must be worked hard for, with both heart and muscle good and true.

The effect of these limited industries is mutually hurtful. As there are no various outlets for labour, its present temporary character demands a higher rate of wages for the time being; conditions that are unhealthy for the producer as absorbing his legitimate profits, and equally so to the labourer, who, having enjoyed enhanced wages for a brief period, has frequently to encounter a succeeding time of distress amounting almost to starvation.

And these facts suggest the immediate conclusion so intelligently drawn in the work I have alluded to, that "much of the labour power we possess is also undeveloped for the want of industries adequate to supply suitable remunerative employment." This want is, the addition of industries that shall be steady and not intermittent—industries that can afford constant employment both for adults and children, by means of which these extremes may be avoided, and by which we may be relieved of very much of our accidental pauperism.

I believe that sericulture will be one important agency in the relief of our present needs, and that, with the material aid of our climate and temperature, it will become at no distant period one of the greatest of our colonial industries.

Until very recently the silk industry has been confined to France and Italy, Syria and Asia

Minor, to China, Japan, and India; and these countries produced a sufficient quantity for the supply of the whole world.

About the year 1853 there appeared symptoms of a disease among the silk worms, which gradually assumed so serious an aspect that led, in 1857, to an advance in China silks of 75 per cent. Since that period the ravages of this disease have so diminished the supply, and enhanced the cost of this product, as to lead to the formation of a Silk Supply Association in London, in February, 1869; a society whose objects were—to stimulate the production of silk in every country where the mulberry tree is capable of giving food to the silkworm, and to give such practical suggestions to all silk-producers as to ensure the greatest care and the utmost possible improvement in quality.

The first action which the Silk Association took was to communicate officially with all the colonies, urging upon them the importance of silk cultivation; and also expressing the desire, by mutual correspondence, both to obtain and to give all possible information on the subject.

And if I may speak of myself, I cannot but say that it was very gratifying to be able to tell the Association that the first step in sericulture had already been taken in this colony, many months before their official letter had arrived.

Having lately received from the Chairman of the Association, his Manual on Sericulture, containing very valuable suggestions, I will endeavour as briefly as possible, from this and from private letters received on the same subject, to indicate the general features of this industry, and to enquire if our facilities with regard to labour and to climate are adapted to its successful prosecution.

And first, as to the silk-producer itself—the worm. There are worms many, but the silkworm is the most beautiful of them all. Of these there are many kinds and feeding upon different plants, such as the alanthus, the oak leaf, the castor oil plant, and even the milk thistle. But among all their generations the most favoured is the worm which feeds upon the mulberry leaf, the *Bombyx Mori*, whose brilliant threads are unequalled by any other fibrous material, and may be designated *par excellence* by the distinctive and time-honoured title of "Silk," as the worms feeding entirely upon any other leaf yield fibres which, although continuous, are very inferior as substitutes, and can be classed alone with spun silk or alpaca.

It is therefore evident that the silk-producing capacity in the worm depends upon the kind and quality of its food. And the reports that have been sent in to the Association from all parts of the globe concur in representing the leaf of the Wild *Morus Alba* as the food especially to be selected; and that while the *Morus Multicaulis* may be given in the earlier stages of the worm, yet that it is more watery and less resinous than the *Morus Alba*, which contains by far the greatest quantity of nutritive and silk-forming substances.

And it is wisely hinted in this Manual that to adopt the wild mulberry tree as the silkworms' food, is to keep as close to nature's process as possible.

The mulberry tree is cultivated in Japan by planting dwarf trees on ridges in lines, at a distance of nearly three feet from each other, the ridges

being between three and four feet apart. They are kept in a dwarf state, the stumps not exceeding a height of 12 or 18 inches above the ground.

The reason alleged by the Japanese for this preference is, that the leaves of the dwarf tree are softer and better adapted for feeding the worms.

Sometimes the trees are permitted to attain a height of four or five feet, when the space between each tree is six feet, and the rows 15 feet apart. This is somewhat closer planting than we have adopted at Magill; but then the Japanese prune their trees very much—cutting down most of the branches every year.

The trees should be manured three times in every year—in January, April, and July.

The most favourable process of raising the Wild Mulberry tree is by suckers from the roots, *i.e.*, pollarding an old tree at a height of about six inches above the ground, so that the tree shall throw out a number of suckers from the roots. Each one of these shoots being separated, with its portion of root, is planted by itself and becomes a mulberry tree. In this way, from one parent tree spring some fifty or sixty shoots.

The trees should be at least three years old before being denuded of leaf. In after years they may be stripped to the extent of at least four-fifths; but much care is necessary to avoid tearing off the leaves, so as needlessly to bleed or injure the tree. A very young tree will yield five or six pounds of leaves; but as it grows older, the crop will measure to one hundred pounds or more. The average yield of an established plantation of eight or ten years' growth, is from thirty to forty pounds per tree; and the average value of the leaves in all silk-producing countries, is estimated at 6s. (six shillings) per cwt.; and considering that every mulberry leaf, wherever grown, may be converted into silk, when duly transposed to the laboratory of the worm, and that the mulberry will thrive in almost every country in the world, it may certainly be said that this tree is worth cultivating.

We can form some idea of the extent of its cultivation, and of the estimation in which it is held, by the following particulars:—

The number of mulberry trees in France devoted to sericulture is 17,000,000, and the weight of the leaves taken from them 400,000,000 lbs, the value of which is 33,000,000 francs. This, therefore, is a question for the agriculturist—the supply of leaves at from 6s. to 7s. per cwt.—for the leaf supply may and should be a business distinct from that of rearing the worm. All the elements of production of silk need not be carried on in any one place—the growth of the mulberry, the education of the worms, and the reeling off of the cocoons, are three distinct branches of sericulture which may, without any disadvantage, be carried on in separate localities, so that the production of the leaf may be made the business of the agriculturist; the education of the worm that of the naturalist; and the reeling process to fall, as it should do, within the department of the manufacturer.

But to proceed. In California the silk-growers already possess 6,000,000 mulberry trees, which are so productive that there are three crops of silk yearly, and the cocoons equal to the highest silk on the continent. As a consequence, large contracts have been made by European "reelers" with Cali-

fornia, for its silk grain. The Legislature has also offered bounties of £60 for each 100,000 cocoons produced, and £50 for each 500 mulberry trees, when at the age of two years; and the amount of land planted last year was limited only by the exhaustion of mulberry stock offered for sale. But the most remarkable report yet received by the Silk Supply Association is from Australia—a report sent through His Excellency the Governor of New South Wales, from a Mr. Brady, of Manles, near Sydney, who says that his success in sericulture is beyond all his expectations, and that for over two years he has never failed a single day, summer or winter, spring or autumn, to have silkworms in every stage.

A Mr. Fenwick also writes from Melbourne, that "silk of a superior quality can be produced there, the climate being all that can be desired, both for the growth of the mulberry and the development of the silkworm."

Such results as these must well excite our astonishment, who, as a sister colony, and under somewhat similar conditions of temperature, are only able to rear two generations of silkworms in the year. It is stated, however, in the Agricultural Report of November last, that Mr. Brady is rearing different kinds of worms, and giving other food besides the mulberry; he mentions especially the *ailantus* plant, and says, "to grow *ailantus* is the easiest of all agricultural or horticultural operations; it is easier to grow than grass. Permanent and constantly improving a plantation of this hardy, prolifically-reproducing bush furnishes a never-failing, ever-abundant, and seasonable supply of the *ailant* caterpillar—the only animal which touches this, its appropriate food, and which is now naturalizing and found to thrive exceeding well in the climate of Australia."

I have written fully to Mr. Brady on this subject, and have also sent for a copy of his work, from which sources I hope to receive much valuable information.

The soil which is described as the most favourable to the white mulberry, is that of a dry, sandy, stony character, having no excess of clay or of chalk. A mixture of humid gravel and sand is also said to be desirable. Another report (from Shanghai) says, "The production of silk is susceptible of indefinite extension; the cultivation does not interfere with other crops, as the mulberry trees grow on the hills in places not available for ordinary AGRICULTURAL PURPOSES."

So that, according to these statements, the soil most adapted to this industry is represented by thousands of acres, scattered all over the colony, which are now valueless, but which might by judicious selection be turned to a most profitable account.

With respect to temperature, it is said that the mulberry tree grown in temperate climates produces more substantial leaves than such as grow in tropical countries. Mr. Davenport in his work quotes from Boullenois a French writer on the vine Worm, who says, "In all places where the vine prospers the mulberry will prosper." The report of the Silk Association also states that "in Japan, as also in France, the most favourable localities for the culture of the leaf and the rearing of the

worms, are the high levels, as being far less affected by the frequent variations of the temperature.

Taking therefore into account these various statements as they stand, from our greater dryness of climate than most other silk-growing countries—a dryness that is greater than in Sydney or Melbourne—I should, as a high temperature locality regard the land most favourable for the mulberry cultivation that extending from Adelaide to the sea, especially in the neighbourhood of the Reeds, on either side of the Torrens, where the soil is always permeated by fresh water at depths varying at front seven to twelve f. ft. Then, as an example of low temperature, we might select large portions of the land now unused in the Mount Lofty ranges, comprising its hilly slopes, and in its valleys every variety of temperature, but all of them of lower degree than the plains.

It will of course be understood that these varieties of temperature are valuable and applicable only to the cultivation of the tree. With respect to the rearing of the worm, an unvaried and uniform temperature is of the utmost importance. We cannot be too clear and too particular on this point, in opposition to the popular fallacy that "nothing is easier than to keep silk worms"—that the successful management of the silk worm requires unceasing vigilance and care, and the exercise of the greatest judgment, and that it requires and is worthy of nothing less than the highest intelligence and the best energies that can possibly be given to it.

The natural conditions of the worm must be carefully studied; they must not be overcrowded, the temperature must be uniform, not exceeding 70° or 75°, the light must be carefully studied, the cleanliness and the ventilation must be perfect, vermin of all kinds and especially mice must be excluded, and the leaves must be fresh and kept dry.

Any neglect of these conditions must lead to disease and to inevitable and severe losses in numbers. But we must not be alarmed or discouraged at the necessity for these precautions.

The successful rearing of the silkworm merely asks for that attention that is required in everything worth knowing or worth doing. This care is especially demanded from the guiding power where the silkworms are kept on a very large scale, on account of the dangers arising from disease, whether it be sickness or dropsy, or worst of all from the disease of the *uji*, a parasite which preys upon the chrysalis, and if neglected will carry off its thousands of victims. A constant vigilance is of course equally demanded from the small cultivator, but in either case the care that is devoted will be abundantly repaid. Its results will meet the wants of a large class for which at present there are no industries in existence demanding their labour.

There is no ostensible work at present for women excepting washing and sewing, and these at the best afford a most precarious subsistence; nor is there any for children excepting service in farm work, which is simply white slavery, for any under twelve or thirteen years of age. This industry would therefore supply a great need, while able-

bodied men would be necessarily required for the commencement of the work, in planting the trees; in the actual care of the worm they are not required at all, neither would they be adapted for it, but women and children would occupy a most useful and important part in the matter, and not only when employed by large cultivators, but also on an independent footing in their own families.

Apart from those of the wealthier classes, who could each devote several sections to the industry there are numerous poor families scattered through the colony, whose work all the year round is very partial, and who—having a few acres of land—could plant it most profitably with the mulberry, increasing their limited incomes.

A person with three or four acres of ground and three or four children ought to add at the very least £10 a year to his income. A thousand trees on 3½ acres of land, thirteen feet apart, would, according to Boullenois, yield leaves for 1333 lbs. of cocoons, which, at current value, would amount to £96; and on a still smaller scale, 300 trees of 4 years old will give at least 10,000 lbs. of leaves to produce 125,000 cocoons at a value of £22 10s. It is also stated that on large farms in France, where labour is paid for, and other farm labour is found at other seasons for the purposes employed, the profit on silk-growing is 15 per cent, but that in farms, where all the work is done by themselves, the profit is 100 per cent. Of course some allowance is to be made in the difference in the price of labour here. Had I been able to devote more time to this subject than it has been possible of late, it was my intention to go far more into detail as to the pecuniary results of this industry on a more extended scale.

The demands upon my time have rendered this impossible; still such considerations as these, which have been so imperfectly added, will I hope be sufficient to bring this matter under our serious consideration as fellow-colonists. Our neighbours in New South Wales have already proposed to make the children attending their public schools devote some portion of their time to sericulture.

I trust that we shall soon be in a position to follow in the same track. Mr. Davenport in his able work has expressed a similar wish:—"There can, I think, be little question that silk cultivation will have a beginning and history in South Australia, and that it will attain here a relative importance from small beginnings to that it has in other countries, suitable to its productions;" and whenever this prediction shall become a verity, all honour should be rendered both to himself and Mrs. Davenport, whose unwearied efforts have been devoted to this subject, and who have taken the lead successfully in obtaining cocoons from the finest description of the Japanese silkworm; the quality of the silk eliciting the highest approval.

I have now, in conclusion, only to express a hope that we may soon be permitted to see this industry begun and carried on upon a scale commensurate with its great importance, as the gains of a remunerative labour, which would relatively ease the cost of family support, relieve the public of much of the cost of destitution, and the destitute of that degenerate moral sense too often attaching upon dependence upon public charity.

PAPER READ BY MR. D. B. ADAMSON, ON TUESDAY EVENING, MAY 31, 1870.

SUBJECT—“REMARKS ON SUN MAPS”

Exhibited before the Adelaide Philosophical Society.

Mr. Chairman and Gentlemen—Having of late years been in the habit of making occasional observations on the sun, and having more than once, under peculiar atmospheric conditions, observed large spots on the solar disc with the naked eye, it occurred to me that by the aid of a few appliances in my possession I might be able to produce a diagram of the sun's disc, showing the principal spots in their relative positions, and giving an approximate estimate of their dimensions.

On the 11th March, as the sun was setting in a hazy atmosphere, I observed, without the aid of any apparatus whatever, what seemed to be a very large sunspot; next morning, on directing my telescope to it, I found it to be, not a single spot, but the largest cluster I have ever witnessed—several other spots also of very considerable magnitude occupied various parts of the sun's disc.

After making several necessary preparations, I was enabled to produce on the 14th March my first sun map, which I now exhibit for your inspection.

Having succeeded so far, and continuing to observe from day to day the rapid changes that were taking place in the spots, it occurred to me that if I could procure another map twenty-seven days later, when the sun would have performed one rotation and would present nearly the same disc to our earth, it would be very interesting as showing what changes had taken place in that time. Circumstances, however, prevented me from making my drawings till the 28th day, so that the places of the spots on the first diagram are one day in advance on the second.

It will at once be seen, in comparing the diagrams, that there is very little correspondence in the spots generally, and that very great changes have taken place—nearly all the large spots shown in the first map having disappeared, and many others broken out in different places—the large group being almost the only remaining feature of the first map, and that also having undergone very considerable changes both in figure and dimensions; in the first map it measures in the direction of rotation about 145,000 miles, whereas in the second it measures very little over 100,000. The total disappearance in so short a time of such spots as those near the lower limb in fig. 1, which present several dark nuclei of a diameter exceeding

that of our globe, betokens a state of very great activity in the enormous forces at work on the sun.

After the vast amount of scientific observation which has been bestowed on this subject by men of the highest talent, aided by every appliance which art could supply (the observations of Schwabe alone extending over a period of about 40 years), it would of course be presumptuous in one like myself to advance any very decided opinion as to the nature or the cause of sun spots, or the purpose in the solar economy which they subserve.

I would, however, remark that if they really are, as they are now almost universally supposed to be, portions of the dark body of the sun seen through breaks or openings in the photosphere and underlying atmospheres, that those atmospheres cannot be of very great depth; otherwise the dark nuclei could not be so plainly seen as they often are, after the spots have approached very close to the sun's limb.

As a proof of their visibility at the times of their approach and recession I would adduce the fact of their often remaining visible to us for the space of thirteen days, after which they are hid from us for fourteen, when they re-appear on the opposite margin.

The cluster represented on the upper, and the spot on the lower limb of fig. 2, give some idea of the close proximity to the margin at which spots may be seen. The dark spots composing the great cluster in fig. 1 could also be seen with considerable distinctness after they had approached very close to the sun's limb, appearing in this position as very narrow dark specks.

The central spots of a large cluster would, however, on account of their greater distance from the surrounding photosphere, remain longer within the line of vision in passing over the horizon, than would the dark bottom of an isolated spot.

From the year 1611, when Fabricius and Galileo independently discovered spots on the sun, the latter making observations on their motions and adding therefrom the time of the sun's axial rotation, down to a very recent date, comparatively little has been added to our knowledge concerning the great centre of our system. The discovery that the spots are subject to periodic fluctuations, and go

through phases of maximum and minimum in periods of about twelve years, is only of recent date, and more recent still is the discovery of the fact that this waxing and waning of the sun-spot period has a close agreement with the variations of magnetic declination, the prevalence of aurora, and in a word, throbs in harmony with all the electrical phenomena of our globe.

The invention of the spectroscope has ushered in a new epoch in the history of solar physics; and, from the startling revelations already made by its assistance, we may fairly expect ere long very great additions to our knowledge of the great centre of our system.

As we are now approaching the maximum of the spot-period, and spots being of frequent occurrence large enough to be visible through a smoked glass, some details of the very simple means employed by me in the construction of my sun maps might be not uninteresting to our amateur astronomers.

In the first place—in a telescope with a power of about 36, which shows the entire solar disc leaving a clear margin all round—I placed a small diaphragm, furnished with cross hairs, corresponding to the squares on the maps. By this means I was enabled to mark each group and spot in its proper place. I then used a $\frac{1}{4}$ aperture reflecting telescope, with a power of 175 to examine and delineate each spot separately.

The spots were measured by the time occupied in their transit over a fine hair stretched across the field of view.

The time was counted by a metronome set to give 136 beats during the passage of the entire disc across the hair, each beat then corresponding to one division of my scale; then by carefully counting the number of beats which occurred during the transit of a spot over the hair, and going through this operation several times in succession for each individual spot, a pretty correct estimate of their diameter was obtained.

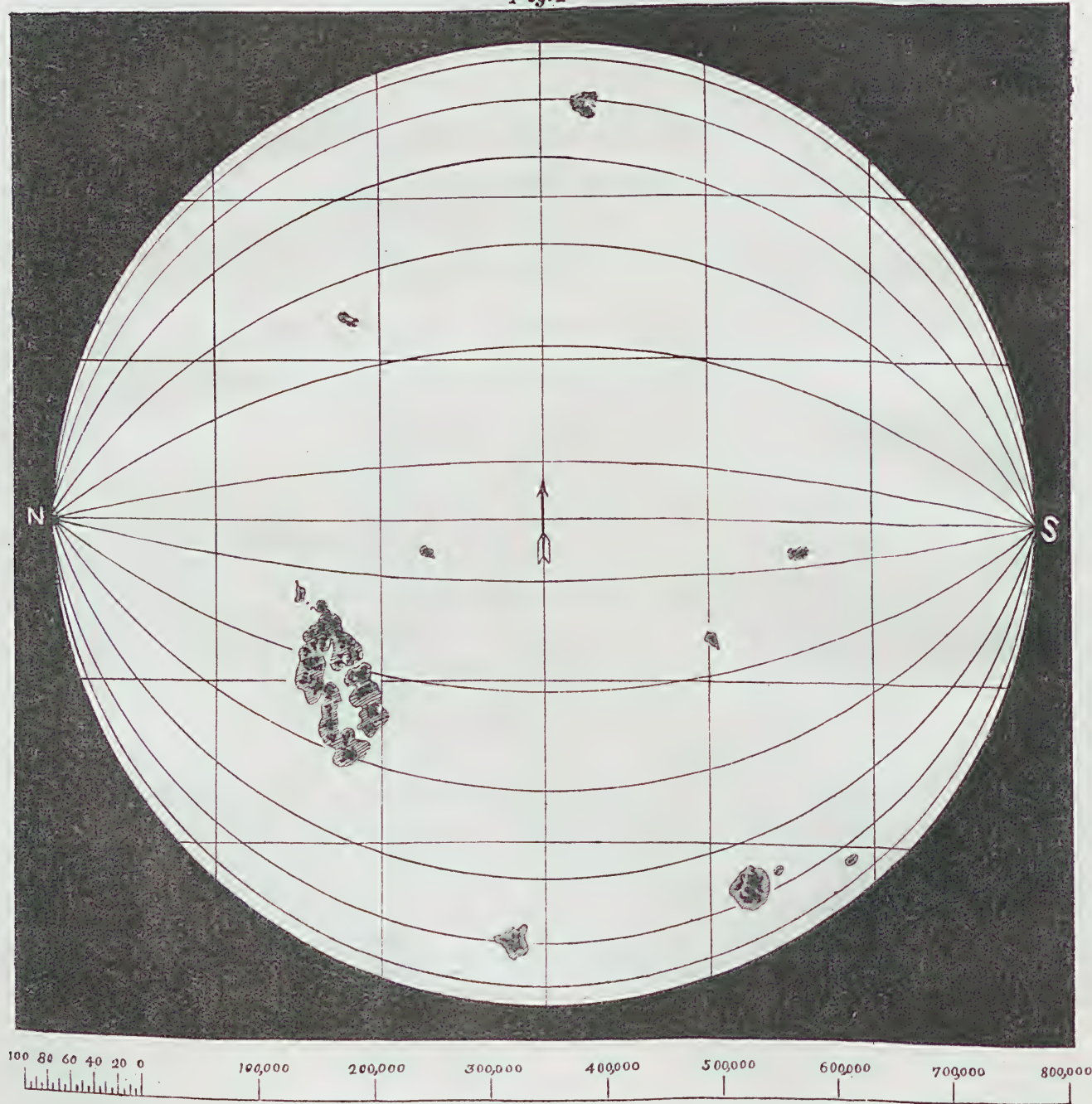
The scale of miles is formed simply by dividing the diameter of the disc by 852,900, the estimated diameter of the sun.

The meridian lines are intended to show the various distances over which a spot will pass in one day on any given part of the disc.

The arrows indicate the direction of rotation.

POSITIONS AND MAGNITUDES OF THE SUN'S SPOTS,
as seen on March 14th 1870 at 9. A.M.

Fig. 1

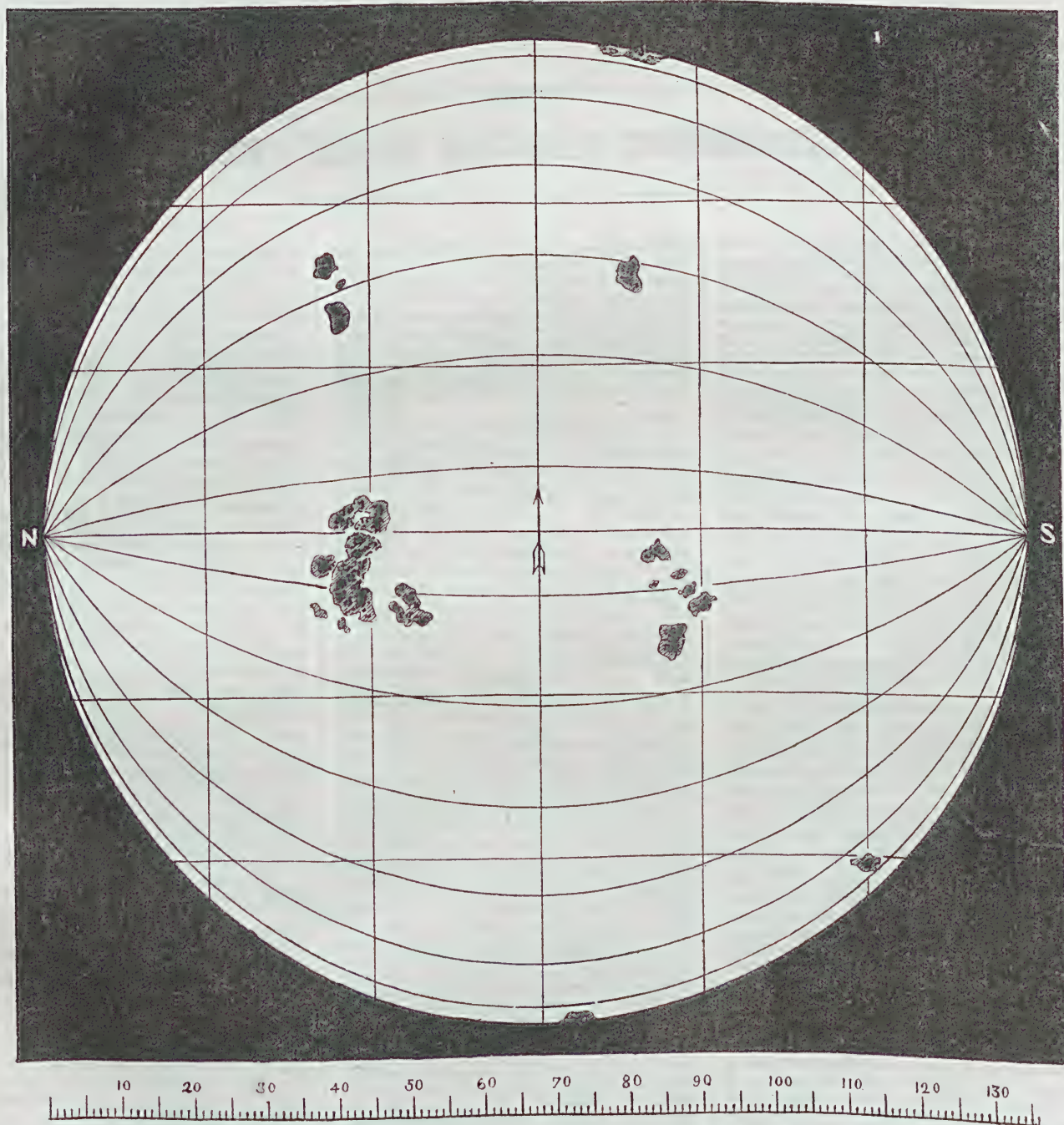


Scale of English Miles.

SURVEYOR GENERAL'S OFFICE, ADELAIDE. Fraser & Crawford, Photo-Lithographers.

POSITIONS AND MAGNITUDES OF THE SUN'S SPOTS,
as seen on April 11th 1870 at 9. A.M.

Fig. 2



Scale corresponding to beats of Timekeeper.

PAPER READ BY MR. R. C. PATTERSON, C.E., ON TUESDAY EVENING, JUNE 28, 1870.

SUBJECT—"LIGHT RAILWAY CONSTRUCTION."

The subject of light railway construction is one that is not only exciting the deepest interest in Europe, and calling forth grave discussion there, but it is also one of very great importance to these colonies, and at this time to this colony in particular, and its importance, I am glad to say, fully recognized by the people and Legislature of this province. I purpose dividing this paper into two parts. First, giving as rapid a sketch as may be of the principles and practice of light railway construction; and then briefly describing the construction of railways under what is known in this colony as the guarantee system. I have primarily to observe that the survey of a proposed line is of the utmost importance, and it is a matter to which few Engineers give the prominence or attention it deserves. The survey of a line is generally pushed on with the utmost expedition, to say nothing of haste; whereas if a light line is the object, and the cost of construction any consideration, it is the last thing in the world that should be pushed. I know of very few lines indeed that have not suffered materially in the cost of construction from this very cause. I have known cases where thousands of pounds have been needlessly expended for the want of a few cross sections, which might have taken perhaps a day's labour; but the Surveyor, mindful then only of pushing instructions received from head-quarters, has driven straight ahead, burrowing into hills and filling deep chasms, causing blasting operations through fine-looking obdurate rock-cuttings for months, and all for the sake of saving a day's labour in cross-sections, and perhaps an additional two days in the setting-out, which would have secured in some instances a surface line, and in others have avoided heavy cuttings and embankments, and expensive waterways. I remember that in making the survey of the Launceston and Western Railway, which for some 12 miles runs through a country requiring most careful and minute survey, Mr. Doyne, the Engineer-in-Chief (a gentleman of European reputation, well-known as the Commander of the Army Works Corps in the Crimea), gave me the most emphatic instructions that I was in no event to sacrifice the smallest detail of survey for the sake of the additional labour or time it would involve, and this, although he was paid not by salary but at a certain rate per mile. The result was that so far as Mr. Doyne's remuneration for the survey was concerned, he might almost have been termed the Honorary Engineer to the Company. Had a less conscientious Engineer, or a less able man filled his position, and the too frequent instructions been issued to push on the survey, and get the work out of hand, the Engineer-in-Chief would have made a

handsome profit out of the survey, and the Company, at an extra expenditure of a few score thousand pounds, would have been able to boast of the heaviest works, the largest, deepest, and most refractory cuttings, and the most troublesome embankments in the Southern Hemisphere. Tasmania has, however, been shorn of this glory, and must rest content with the knowledge that the glory, if obtained, would have been very costly, and not worth the money after all.

M. Richard, in a paper read before the Society of Civil Engineers in France in 1869, makes some useful general remarks on local railways, which my time will not allow me to more than refer to. The paper alluded to is "On Local Railways," and is to be found in the *Annales du Génie Civil* of last year. We shall undoubtedly agree with him where he states that economy will be at a maximum, if we can avoid earthworks and works of art, which can be done by adopting a contour of the country by means of sharp curves, and by following as nearly as possible the natural level of the ground. This is undoubtedly the correct principle for laying out lines, which will involve the least possible expenditure in their construction; but the principle should not be followed too closely. I am afraid there is a great tendency in these days of mechanical improvements in the locomotive to make light of steep gradients. It is true that the experience of late years has proved that gradients and curves which were once deemed prohibitory are now workable with facility; but it is none the less true that heavy gradients demand an increased weight of engine and a proportionately heavier road, and entail serious additions to the future cost of working. Three or four gradients of 1 in 50 on a line of easy gradients otherwise, are quite sufficient to completely alter the type and weight of locomotive that would else have sufficed to work the traffic of the line. If I were in charge of any of the surveys of the proposed new lines, and found that I could obtain ruling gradients of 1 in 100, with few exceptions, I would feel inclined to largely sacrifice the cost of construction at those points in order to keep down the weight and power of locomotive required, and so save the future working expenses of the line.

As a case in point, I would instance the Northern Extension Railway to the Burra, which is a very light type of line, constructed with 40-lb. rails. This line starts from Roseworthy, and the steepest gradient from Roseworthy to the terminus at the Burra is 1 in 80. Similarly between Adelaide and Gawler, a distance of 24 miles, the steepest gradient is 1 in 90. But on the six miles between Gawler and Roseworthy several heavy gradients occur, the

ruling gradient being 1 in 62. As a consequence, much heavier engines have to be used to work this portion of the line six miles in length, than are required to work the other 96 miles. Besides this, there is always the temptation to run the heavy engines on the new line, the permanent way of which is not strong enough to carry them. As a matter of fact, the heaviest engines that run on the North line from Adelaide to Kapunda have, in several exceptional instances, run on the extension line at reduced speeds. If the Northern Extension line had been surveyed and set out so as to start from Gawler, which would have been the proper junction, there would have been no gradient steeper than 1 in 90 on the whole 105 miles from Adelaide to the Burra, and the extra length of the extension line caused by avoiding these heavy gradients would have been three and a half miles; but the through distance from Adelaide to the Burra would have been shortened. As it is now, the Burra traffic will have to be hauled up heavy gradients for six miles to a summit-level for no earthly purpose except to descend again in the next few miles. I have given prominence to this point, as I know from experience how seriously the conduct of traffic on heavy gradients interferes with the economical working of a line.

From all the information I can obtain about the country in the South-East and the district for 200 miles north of Port Augusta, I am led to infer that there is no necessity for the adoption of steeper gradients than 1 in 100, and, if possible, nothing steeper than 1 in 80 should be permitted unless the sacrifice in the cost of construction should prove greater than the probable saving in the working expenses would justify; and this, of course, would be a simple matter of calculation.

It is not necessary practically to set any limit to the radii of the curves to be allowed. There are numerous curves of 330 feet radius on the Queensland line, round which the engines fitted with Adams's radial axle-boxes or the Bissel truck run with safety and facility. We are not likely to require curves of anything like so sharp a radius in this colony. I should have said that in considering this question of light railway construction I meant to confine myself entirely to the requirements of this colony, and it must be borne in mind that I by no means wish to advocate the class of railways I am about to describe and advocate for South Australia as applicable to the more thickly populated and better settled districts of the neighbouring colonies. Nor do I consider the type of line I am about to describe as suited for the extension of the existing Northern line, and that for reasons which will appear obvious in the sequel.

My remarks will be entirely directed to light railway construction in those portions of this colony where there are no lines at present, and where if lines were constructed, there would be but little chance of their ever being connected with the existing main lines of the colony; the South-Eastern District, for example, or the country north of Port Augusta.

Taking these two districts, therefore, as being the only portions of South Australia through which railways are likely to be made for some years to come, I would remark first, that I would recommend the adoption of a gauge of 3 feet 6 inches, and that for the following reasons:—There can be no doubt whatever that a line of that gauge is more than adequate to meet the requirements of any district in this colony; and it is pretty certain that its extreme capabilities will remain an unknown quantity for many years to come, so far as any practical test of its capacity can be supplied by the commerce of the district through which it passes, or the traffic it may send over the line. A line of this gauge costs less to construct and very much less to work and maintain than a line of the ordinary gauge of the colony.

I hope to be able to bring these points out as I proceed. I may say here that I was engaged for nearly three years upon the construction of the Queensland railways, which have a gauge of 3 feet 6 inches, so that I am thoroughly conversant with the details of the construction and working of a line of that gauge.

The earthworks of a railway vary of course with the nature of the country through which the line passes; but in the South-Eastern District, and also I believe in the Northern, the item would be a small one. The width of cuttings and embankments at formation level should be 12 feet 6 inches and 14 feet respectively.

On the Northern Extension line (5 feet 3-inch gauge), which is all but completed, the formation widths are 16 feet 6 inches in cuttings and 18 feet in embankments. I believe the lines in the Northern and South-Eastern Districts would for the most part consist of embankments made from side cutting; and a moderate-sized ditch on each side of the line would in most cases provide sufficient material for the embankments, and at the same time effectually drain the line.

The permanent way, which, as is generally known, is of paramount importance, should consist of a single line of way throughout with rails of the Vignole's section, 40-lbs. to the yard, carried on rectangular cross-sleepers 6 feet 6 inches long, 9 inches wide by $4\frac{1}{2}$ inches deep, spaced 2 feet 6 inches apart centre to centre. The rails should be fished at the joints with Adam's patent bracket plates, and secured to the joint sleepers by fang bolts. At the intermediate sleepers the rails should be secured by $4\frac{1}{2}$ inch dog spikes; there should be 3 inches of ballast under the sleepers when the line is completed, with a top width of 8 feet. A very similar permanent way to the above was adopted in Queensland, and it has stood very well. In the event of heavy gradients being indispensable, and occurring on the new lines, I should recommend the use of a slightly heavier rail, say 50 lb. to the yard, to be put down upon the inclines only. I should also feel disposed to use a 50-lb. rail at all stations where there was likely to be much shunting, or better still perhaps, in both instances, a 40-lb. steel rail, as I am convinced it would be the truest economy in the end.

This brings me to the consideration of the rolling-stock which would be suited to such a

permanent way, and at the same time be equal to the conveyance of all the traffic the district is likely to offer. It is advisable that the stock should be so constructed as that no axle could have more than 5 tons on it, or in other words, that no wheel should press with greater weight upon the rail than $2\frac{1}{2}$ tons.

In general terms, it may be said that the rolling-stock which suits this condition will meet the requirements and keep fairly within the capabilities of the permanent way I have described. Keeping this main principle in view, it will be necessary to ascertain the type of engine that will at once meet this requirement, and at the same time have sufficient tractive power to take, say 100 tons up 1 in 100 at the rate of 10 to 15 miles per hour. The Norwegian 3 feet 6 inch gauge lines have tank-engines, some fitted with the Bissel truck or bogie, and others with Adam's radial axle-boxes, which are capable of performing this duty. They have outside cylinders, and most of these are of the following dimensions:—Cylinders, 10 inches in diameter, 18 inches stroke. Six wheels—four coupled—3 feet diameter, and leading wheels 2 feet in diameter. Their full weight ready for service is only 14 tons. Mr. Charles Fox, writing of these engines, states that a train he travelled by on the Norwegian narrow-gauge weighed with the engine 118 tons, and ran considerable distances at 30 miles an hour with smoothness and steadiness. I myself have travelled over 30 miles an hour on the Queensland railways in a train drawn by an engine of very similar power to the above. An experiment was made in Norway early this year to determine the tractive resistance on the 3 feet 6 inch gauge. The engine used was of the Bissel bogie type, having a pair of side tanks holding 300 gallons of water and a coal bunker having a capacity of 23 cubic feet extending across the trailing end. The cylinders were 11 inches diameter and 18 inches stroke, driving wheels of 3 feet 9 inches in diameter, with a Bissel truck having single pair of 2 feet diameter wheels in front. The engine weighed sixteen tons nineteen hundredweight, of which twelve tons seventeen hundredweight were on the coupled axles and so available for traction. With this engine Mr. Pihl, the Norwegian Engineer-in-Chief, has run at 40 miles per hour without experiencing any inconvenience. The train consisted, besides the engine, of sixteen plank trucks, weighing loaded $8\frac{1}{2}$ tons each. The trucks were 26 $\frac{1}{2}$ feet long over all, with wheel base of 13 feet. The total length of the train was 444 feet, and the total weight of train including engine was 149 tons. This train was taken up an incline $2\frac{1}{2}$ miles in length, the first mile and three-quarters being a gradient of 1 in 118, and the last mile 1 in 100, with curves of 15 chains radius. The speed on the first gradient was fourteen miles an hour, which came down to ten miles an hour on the steeper gradient; the boiler pressure being 100 to 120 lbs. An engine with the same sized cylinders as the foregoing, but constructed to run with a tender, so that the weight on an axle would not be more than five tons, would, I think, more than suffice for the requirements of any new lines that may be carried out in this colony. There are two or three different classes of engines used on the Queensland railways. Tender engines weighing 15 tons in working order were employed when the line was first opened. These engines are upon six wheels. The driving and trailing wheels are coupled, and are three feet in diameter. The front is fitted with a Bissel-truck having single pair of wheels 2 feet in diameter. The cylinders are 10 inches in diameter, with a stroke of 18 inches. Others of these engines with the same sized cylinders have the driving-

wheels in front, and the trailing-wheels fitted with Adams' radial axle-boxes. The tenders are 10 feet in length, carry 450 gallons of water, and have 70 cubic feet of space for wood and coal. They weigh seven tons when full, and are carried on four wheels. These engines can take 90 tons on a line having ruling gradients of 1 in 100, at 15 miles per hour. Their cost free on board ship in England was £1,400. They have been found altogether too light for working the 1 in 50 gradients, and it was two of these engines I recommended the late Government to purchase from Queensland for working the Port Wakefield Railway. They were offered at £1,200 each. Another and more powerful class of tender-engine is now in use, with cylinders 11 in. in diameter and 18 in. stroke, weighing 20 tons in working order, and carried upon eight wheels. Six of these wheels are coupled, they are 3 feet 3 inches in diameter, and are placed so close together that the wheel base is only 7 feet 2 inches in length, the centre pair of wheels are without flanges. This engine has a Bissel bogie in front with wheels 2 feet in diameter. The tenders are 12 feet long on four wheels; they carry 600 gallons of water, and have 100 feet of space for coal and wood; they weigh when full nine tons. The cost of these engines when complete, with tender free on board ship in England was £1,800. The Fairlie engines sent out by Sir Charles Fox for working the Main Range Incline were a complete failure, not from any fault of the system invented by Mr. Fairlie, but on account of the bad design and workmanship of Messrs. Cross & Co., the makers. These engines weigh 38 tons instead of 30 as stipulated in the specification. My friend, Mr. Jetter, the able Locomotive Superintendent of the Queensland Railways, writing to me last year said:—"The first and only one of the three we tried proved far too heavy for our rails, and damaged them so much that over two dozen had to be taken out after the trial." Mr. Fairlie repudiates all connection with them, and states that he had nothing to do with either their design or construction. It is a fact now that some later engines constructed under his supervision have been a great success, and if greater tractive power is required than is possessed by the ordinary engines I have described (which is violently improbable), that extra power can be obtained by engines constructed on Mr. Fairlie's system, with adherence still to the principle with which I started; that no wheel should press upon the rail with greater weight than $2\frac{1}{2}$ tons.

I cannot give a general idea of Fairlie's engine better than by simply saying that it has one long boiler, with two sets of tubes and a double firebox between, and that the weight of the engine is carried upon two independent bogies or trucks, upon the centre of which the locomotive is poised.

The bogie is a low flat table or truck upon four wheels, with a pivot in the centre, through which the weight is transmitted to the truck. The advantage claimed for the bogie is that it almost entirely annihilates the oscillation which is the cause of so much damage to the rails of the permanent way. As with ordinary carriages and wagons, the weight rests entirely on the journals or ends of the axles; so with the ordinary locomotive, and irregularities in the permanent way disturb the plane of motion and cause the locomotive to sway to and fro transversely, or rock from side to side with greater or less violence, as the case may be, and hence the term "oscillation." The oscillation of trains running at high speed acts very severely on the permanent way, and the consequent hammering of the wheels on the rails is one of the main causes of their wearing out so quickly where there is a heavy traffic.

It will be understood that if the weight could be taken from the ends of the axles or journals, where it now directly presses, and transferred by any means to a point which would represent the centre of the permanent way, there would be less of that hammering action on the rails to which I have referred, and less oscillation altogether. The lowering of the centre of gravity of the engine is also another very important point, and all this has been accomplished by means of the double bogie. Further, the application of the double bogie to locomotives renders it possible to traverse curves of, I may almost say, any radius. Mr. Fairlie has laid down a curve of 50 feet radius in a small cabbage garden at Hatcham, half an acre in extent, round which a steam-carriage, 43 feet in length, has travelled at a speed of 25 miles an hour with ease and safety.

A locomotive resting directly upon wheels of its own would make a long rigid wheel base that could not by any possibility get round sharp curves. There are some locomotives on the South Australian Railways with a rigid wheel base of 15 feet in length, and one has only to travel on such an engine round the sharp curves of 10 chains radius near Kapunda to become very sensible of the destruction that must result to the permanent way were such engines to be used for the conduct of the ordinary traffic on that portion of the line. The engine certainly does get round the curves, but it is with an amount of flange friction that is utterly destructive to the road, which retards speed, and which expresses itself by an excruciating grinding noise, telling only too audibly of the damage that is being done. Now, in the case of the Fairlie locomotive, the engine is poised, as I said before, on two independent trucks, which have a very short wheel base, and which therefore can have no difficulty in accommodating themselves to the sharpest curves that can ever occur in railway practice. To sum up briefly, I may state that Mr. Fairlie claims for his locomotive enormously increased power over the ordinary type of engine, with great facility of traversing the sharpest curves, and with a freedom from oscillation that makes his engine less destructive to the rails than engines of much less power and weight after the ordinary type; and judging from the records of the experiments made in England in February of this year, we are bound to believe that he has established his case. I will now give you the result of a trial of an engine on the Fairlie principle on the Festinog line in North Wales, as against one of the ordinary engines in use on that railway. Every one has heard of this wonderful little line of 2-foot gauge. The Welsh Pony was the name given to a locomotive which was selected to represent the common type of engine. It was a four-wheeled locomotive, weighing 10 tons, with 8½-inch cylinders, and 12 inches stroke, wheels 2 feet in diameter. Fairlie's engine was called the Little Wonder, and was an 8-wheeled double-bogie engine, with four cylinders 8½ inches diameter and 13 inches stroke, wheels 2 feet 4 inches in diameter, and weight 19½ tons. Each bogie has a wheel base of 5 feet. The Welsh Pony with its train having been run on to a gradient of 1 in 85, was brought to a standstill, and then made to start on the gradient with a load of 26 wagons, the total weight of the train, including engine, being 73 tons 16 cwt.; and this was found to be the limit of this engine's power. It started up the gradient and carried the load as far as was considered necessary at the rate of five miles per hour; boiler pressure averaging 150 lbs. to the inch. The Fairlie engine Little Wonder was then loaded with a train of 72 wagons of slate, weighing 138 tons 17 cwt., and with empty ones

weighing 43 tons 18 cwt., this, together with the weight of the engine, making up a total load of 206 tons. The Little Wonder, with its train, was brought to a standstill on the 1 in 85 gradient, as with the former train, and started on the gradient and took up its load successfully (but whether at the same speed as the Welsh Pony is not stated), the average steam power being 150 lbs. Mr. Fairlie calculates that the Little Wonder is equal to the carriage of 450 tons on the level at a speed of 14 miles per hour. I should have said that these experiments were made in the presence of the Duke of Sutherland, the Russian Imperial Commissioners, the Commissioners of the Indian Government, and of Captain Tyler, the Inspector of the Board of Trade. On the next day the performances of a Fairlie engine on the Mid-Wales Railway, having a gauge of 4 feet 8½ inches, were no less striking than the results we have seen on the Festinog line of 2-foot gauge. The locomotive in this case was called the Progress, and was a double engine, with a four-wheeled bogie under each end. There were four cylinders 15 inches diameter, 22 inches stroke. The bogie wheels were coupled together in each truck, so that all the wheels in the engine were drivers. They were 4 feet 6 inches in diameter. In this trial, before the same Commissioners, the Progress took a total load, including the engine, of 526 tons, from the Three Cocks Junction to Builth, a distance of 14 miles, in an hour, which included stoppages. There were several up-gradients and reverse curves; amongst the gradients were 1 in 75, 1 in 90, and 1 in 162. On the same day she took a load of 180 tons up a gradient at 1 in 35 for half a mile, and then 1 in 38 for 6½ miles. I have brought the result of these trials under your notice simply for the purpose of showing the enormous power of engines constructed on this principle. Before leaving the question of locomotives allow me to revert for a moment to something more in harmony with our requirements in this province. Mr. Pihl, writing of the Dramen line, states that—"It has two small locomotives with a weight of only eight tons on driving wheels, or two tons on each wheel—that is, not more than the weight of a loaded wagon. These engines have been placed on the line to work the light passenger trains, for which they have proved themselves exceedingly adapted, and also as experimental engines for lines of the smallest amount of traffic, justifying railways as the medium of transport in place of common roads." The principle Mr. Pihl proposes for such lines is, that in place of the locomotive being the standard from which the structure has to be proportioned, he takes the weight of a loaded wagon, and the permanent way he proposes to lay with rails of 30 lbs. to the yard. There is no doubt that this principle can be carried into effect where lines have to be made through thinly-peopled districts, having a very limited amount of traffic. The principle I laid down in the beginning of this paper, viz., that no wheel should press with greater weight on the rail than 2½ tons, is but very little in excess of Mr. Pihl's standard of two tons to the wheel. If we can keep the weight of the rolling-stock down to this, there is no reason why the Port Augusta and South-Eastern lines should not be laid with rails of 30 or 35 lbs. to the yard. I have taken a 40-lb. rail, so as to be on the safe side, and because I know that locomotives sufficiently powerful to work the proposed new lines can be constructed with no greater weight than 2½ tons on any wheel.

In Queensland the passenger stock is of the very best English manufacture, and is very expensive, and I am inclined to think that the

Norwegian passenger stock will better suit the requirements of a country like this.

Besides the ordinary wagons 14 feet in length on four wheels, the Queensland Railways have low-sided wagons on three pairs of wheels 20 feet long 6 feet 6 inches wide, that carry 23 bales of wool, and 30 feet trucks also on three pairs of wheels, that carry 35 bales of wool; the weight of the former is five tons, that of the latter six tons. The underframes of this stock are of angle iron 6½ in. by 3½ in. x ½ in. The covered wagons 14 feet long weigh 3 tons 10 cwt., and carry 6 tons; the ordinary low sided-wagons are 14 feet long, weigh 2 tons 10 cwt., and carry 6 tons also. Contrast the dead-weight of the covered wagons and low-sided trucks on the South Australian Railways, which carry the same paying load, with the above, and the result will be found to be startling indeed.

Descrip- tion.	Gauge.		Dead load.	Paying load.
Covered	ft. in.		Tons cwt.	Tons.
wagons...	3 6	Queensland	3 10	6
Do. do...	5 3	S. Australia	4 13	6
Low-sided				
wagons...	3 6	Queensland	2 10	6
Do. do...	5 3	S. Australia	4 4	6

These facts alone will explain one great cause of the economical working of 3 feet 6 inch gauge railways. The matter is so transparent that it is not necessary for me to enlarge upon it. I may state that the weight I have given of 4 tons 4 cwt. is that of the low-sided wagons imported last year for the Northern Extension line. In some respects the carriage and wagon stock of the Norwegian 3 ft. 6 in. gauge lines are, I think, to be preferred to the Queensland stock. The carriages, on account of their greater simplicity and cheapness, and the wagon-stock, because of one or two peculiarities in detail, which have great originality and merit, and tend to cheapen the cost of this stock. I do not think, however, that the Queensland wool-trucks on six wheels could be improved upon for this colony.

The passenger-carriages in Norway on this gauge are constructed to carry the same number of passengers as on the English 4 ft. 8½ in. gauge, and are made for two classes of passengers only, the compartments being fitted and furnished to correspond with an English first and third class. The goods wagons were constructed with bodies about 6 ft. 6 in. in width, and were made to carry six tons. This width is but little short of that attained by the wagon-stock of the 4 ft. 8½ in. gauge, and was obtained by having the springs attached to brackets inside the sole bars, this arrangement allowing also for the lowering of the body, and at the same time, of course, bringing the centre of gravity nearer the rail. A single central buffer was adopted, which also formed the drawbar; and the couplings have been made so as to be self-acting when the wagons are pushed together. This buffing and coupling arrangement is at once simple and effective. The ends of the drawbars have buffer-heads forged on them, each head having a recess formed in it on the upper side. This recess at one end of the drawbar is furnished with a hook, which, when down, fits a notch at the bottom of the recess in the buffer-head of the next wagon, and it is secured from rising by a small chain looped over it.

Mr. Pihl has made the following table showing list of prices, weight, carrying capacity, &c., of carriages and wagons on the 4 ft. 8½ in. and 3 ft. 6 in. gauge railways in Norway for the purpose of comparison:—

Description.	Gauge.	Price.	Length.	Width.	Weight.		Carrying capacity.	Weight of passenger carriage per ton.
					Total.	Per ft. run.		
Composite, 1st & 2nd class	ft. in. 4 8½	£ 323	ft. in. 20 0	ft. ft. 7 3 & 8	6.4	1.6	32	4.0
Do., do. ...	3 6	230	20 0	6 10 in	5.45	1.6	32	3.4
Second-class carriage ...	4 8½	240	20 0	7 3 & 8	6.02	1.4	28	4.3
Do., do. ...	3 6	131	20 0	6 10 in	3.80	1.4	28	2.7
Low-sided wagon ...	4 8½	90	16 0	ft. in. 7 4	4.15	7.5	6	1.45
Do., do. ...	3 6	64	16 0	6 6½	3.3	7.5	6	1.82
Plank-timber wagon ...	4 8½	90	18 0	7 6	4.4	6.7	6	1.33
Do., do. ...	3 6	62	18 0	6 6½	3.0	6.7	6	2.00

The lengths of carriages and wagons in this table are exclusive of buffers, which project 18 inches on each side beyond the body on the 3 feet 6 inches gauge. The chief part of the wagon-stock is constructed for carrying timber and deals, which, as is well known, is the staple article of transport on the railways in Norway. For this reason most of the trucks have to be very long (from 18 to 23 feet), and the load limited to five and a half or six tons, thus necessitating a long and consequently heavy wagon, as compared with the paying load. Mr. Pihl states that if the traffic had been of a more weighty nature—minerals, for instance—allowing the load to be carried low and concentrated, the wagons would have been constructed so that the dead load relative to the paying load would have been greatly reduced. On analysing this table it will be found that the composite carriages on the 3 feet 6 inches gauge, of the same length as those on the ordinary English gauge, carrying the same number of passengers, are £100 cheaper, and weigh a ton less. And the second-class carriages on the narrower gauge cost over £100 less, carry the same number of passengers for the same length of carriage, and weigh 2½ tons less than the same class carriage on the 4 feet 8½ inches gauge, and similarly with regard to the wagon-stock. The low-sided wagons on the 4 feet 8½ inches gauge cost £90, as against £64, the cost of the same class wagon on the 3 feet 6 inches line. They are each constructed to carry six tons, and the weight of the broader gauge stock is 4.15 tons, as against 3.3 tons on the gauge I am advocating. (This same class wagon to carry six tons only, weight 2 tons 10 cwt., on the Queensland lines.) The like comparison will hold good with the timber wagons on the different lines. I must confess that I am unwilling to lessen the force of the foregoing by making any elaborate remarks on the results of the comparisons, and I will therefore pass on at once to the examination of the cost of railways constructed on the 3 feet 6 inches gauge. In

Norway Mr. Pihl has constructed two lines of this gauge, one from Grundset to Hammar, a length of 24 miles, passing through a tolerably easy country. It has ruling gradient of 1 in 70, with curves of 1,000 feet radius; and the cost, including rolling-stock, stations, and workshops, was £3,142 per mile. The stock provided for this amount was three locomotives, six passenger carriages, three brake-vans, and 50 goods wagons, with ballast-wagons, repairing shops and tools, two terminal stations, and six intermediate stations. The second line from Thronbjem to Storen, 30 miles in length, passes through a difficult country. The earthworks are very heavy, and there are twelve large bridges. The gradients are severe, there being five miles of 1 in 52, four miles of 1 in 42, followed by four miles of 1 in 65. The total cost of this line, including rolling-stock and stations, is given at £5,300 per mile in *Engineering*; £6,000 per mile, according to Mr. Charles Fox, Mem. Inst., C.E.; and £7,000, according to the *Engineer*. I am not in a position to say which of these statements is correct.

In Queensland 192 miles of railway of the gauge I am advocating for this colony has been constructed. The works on some portions of the line are very heavy, especially in crossing the Little Liverpool Ranges, and further on in crossing the main range. The incline leading to the tableland beyond the main range known as the Darling Downs is 16 miles in length, and has ruling gradients of 1 in 50 with numerous curves of five chains radius. There are 10 tunnels on this portion of the line alone if I remember rightly. The longest tunnel is through the Little Liverpool Range, and is a little over a third of a mile in length. I was engaged upon these works almost from the beginning, and until the completion of the second section. At first for the contractors, Messrs. Peto, Brassey, & Betts, and subsequently for the Government under Mr. Fitzgibbon, the Engineer-in-Chief. The cost of the seventy-eight miles to the tableland at the head of the main range averaged £13,700 per mile. This amount includes rolling-stock, stations, and every expense. The cost of the remaining 114 miles varied from £6,000 to £7,000 per mile, including everything.

With regard to the construction of light lines of a 3 feet 6 inch gauge in this province, I would remark first, that in traversing even tolerably level country there is a much greater difference than is generally imagined between the cost of constructing a line on the 3 feet 6 inch gauge, and that of a line on the ordinary gauge of the colony. There is also a saving in the cost of the rolling-stock, and a still further saving in the greatly-diminished expense of working and maintenance.

I cannot exemplify the difference in the mere cost of construction better than by taking the Northern Extension Railway from Tarlee to the Burra, and showing what the difference would have been had that line been entirely isolated from other lines, and been made on a gauge of 3 feet 6 inches, with the same weight of rail. I find that the earthworks on that railway amount on the average to 8,120 cubic yards to the mile, costing £445, and the masonry, in culverts and bridges, amounts to £250 per mile. If the line had been constructed of the narrow gauge, with the formation widths as indicated by me in the beginning of this paper, the earthworks would only have amounted to 6,490 cubic yards, costing say £356 as against £445 on the existing line; the masonry would have been £220 as against £250, and the permanent way would have been £320 less; and so the saving on the construction merely would have been say £440 per mile, or £22,000 for a length of 50 miles. I have made use of the Northern Extension line so far simply to obtain a reliable basis

from which to proceed. The earthworks and masonry of that line have been completed for about four months, and the permanent way is laid to within three or four miles of the terminus at the Burra. The figures I have given, therefore, of the respective values of earthworks, masonry, &c., are not estimates which may be exceeded; but they are absolute facts, and my deductions, therefore, may be accepted as reliable.

I do not know the country North of Port Augusta, but I am informed that it is exceedingly well adapted for the formation of a railway, and that the earthworks and masonry would not be more than one-half the amount of those items on the existing Northern Extension line. The longitudinal section cannot well be lighter than that, as one-half the quantity of earthwork would only give 2.3 cubic yards to the yard forward on a line of the same gauge. I will assume, then, that the earthworks of the proposed Port Augusta Railway will only average half the quantity per mile of the Northern Extension line, and I will also take it for granted that this line on a 5 feet 3 inch gauge can be constructed within the estimate of Mr. Wallace, who asked the Government to guarantee 6 per cent. interest on an expenditure of £1,000 per mile (*vide Evidence Port Augusta Railway Bill, 1867*). I have no doubt whatever that Mr. Wallace abundantly satisfied himself that the work could be executed for that amount. Taking, therefore, the cost of this line on a 5 feet 3 inch gauge, with a 10-lb. rail to be £4,000 per mile, including rolling-stock, stations, workshops, &c., the amount saved in the construction by adopting a gauge of 3 feet 6 inches, would be £380 per mile. I will now examine the saving that would be effected in the rolling-stock. To properly stock the line there would be required 12 engines, 12 carriages, three brake-vans, and 300 trucks of various sorts. To many people this would seem at first sight a poor allowance of stock to work a line of 200 miles in length, but when it is remembered that the Port Augusta Bill of last session only bound the Company to run trains for passengers over the railway from one end to the other of the line twice every week at the rate of not less than 10 miles per hour, and three weekly trains for goods through the whole line at whatever rate of speed they pleased, it will be seen that the stock I have put down is excessive.

The following would be the respective values of the rolling-stock for the different gauges:—

Taking the 5 feet 3 inch gauge first.	
12 locomotives, at £2,250 ...	£27,000
12 carriages, at £410 ...	4,920
3 brake vans, at £300 ...	900
300 trucks, at £110 ...	33,000

£65,820

Three feet 6 inch gauge.	
12 locomotives, at £1,750 ...	£21,000
12 carriages, at £310 ...	3,720
3 brake vans, at £200 ...	600
300 trucks, at £80 ...	24,000

£49,320

A difference of say £16,000 in the whole length, or £80 per mile. The narrow gauge line would thus cost £460 less per mile than a line of the gauge proposed in the Bill, with rails of 40 lbs. to the yard, or a saving in the total length of £92,000. It would surely be great folly to construct a line of the 5 feet 3 inch gauge at such an extra cost when a line of the narrower gauge could carry a month's traffic of the district in a single day, and especially would the folly become more obvious when it is remembered that the expense of working and maintaining the narrow gauge line is beyond comparison less than the expense of working and

maintaining a line of the standard gauge of this colony. It appears, therefore, that a 3 feet 6 inch gauge railway for the proposed line 200 miles north of Port Augusta would cost £3,540 per mile, but that amount does not include either fencing or a line of telegraph. It is presumed that fencing will not be required in the desert, and if the line is ever constructed it will be able to use the overland telegraph to Port Darwin about to be made in connection with the Telegraph Maintenance and Construction Company.

As Mr. Wallace's estimate of £4,000 per mile must have included the expenses of the English Directory, as well as the more costly local Directorate and many other expenses which are inevitable in connection with a guaranteed Company, I think it very possible that this line could be carried out largely within his estimate of £4,000 on the 5 feet 3 inch gauge by the Government, and consequently the line of 3 feet 6 inch gauge could be carried out for a corresponding less amount than the sum I have placed down for it, supposing it to be undertaken by the Government. Before leaving this portion of my subject I wish to make a few remarks upon the use of a 40-lb. rail for railways having a gauge of 5 feet 3 inches, such as that of the Northern Extension line, where a rail of this weight is used. My experience of the 40-lb. rail convinces me beyond a doubt that it is not sufficiently heavy for a line of the ordinary gauge of the colony, although it is amply sufficient for the narrow gauge line I have been describing. Most of the engines that have been running over the Northern Extension Railway, in conveying materials for the construction and working the passenger and goods traffic, have had over eight tons on an axle, or more than four tons per wheel pressing on the rail; and I am satisfied that nothing less than a rail of 55 or 60 lbs. to the yard will suffice for the carriage of such rolling-stock. I know this will be gainsaid by many who think the 40-lb. rail quite as heavy as the rail need be; but I have had exceptional opportunities of studying the character and capabilities of a 40-lb. rail, and I very much question whether any one in the province has had as much experience of this rail as myself. The extra cost of laying a 60-lb. rail on the Northern Extension Railway would have been about £320 per mile. To rightly ascertain the difference, therefore, between the cost of lines of 5 feet 3 inch and 3 feet 6 inch gauges, the one should be taken as having a rail of 60 lbs., and the other a rail of 40 lbs. to the yard. For a line of the 3 feet 6 inch gauge with a 40-lb. rail, and the weight of stock it has to carry is relatively as strong, if not stronger, than a line of 5 feet 3 inch gauge having a 60-lb. rail, and taking the weight of the stock it has to bear. Taking this view of the subject, therefore, and still assuming that the cost of the Port Augusta line, 5 feet 3 inch gauge, with rails of 40 lb. to the yard, at £4,000 per mile, it would cost with rails of 60 lb. to the yard £4,320 per mile. This, then, would be the cost of this line on the 5 feet 3 inch gauge, to compare with £3,540, the cost of an equally strong line relatively to the stock it has to carry of the 3 feet 6 inch gauge, showing a saving in favour of the narrow gauge line of £780 per mile, or a total saving on the whole length of 200 miles of £156,000.

Having thus described as briefly as I have been able the principles and practice which in my opinion should be observed in the construction of light railways in this province, I propose still more briefly to give you a few notes I have made as to the construction of railways on what is known in this colony as the guarantee system. I will take as the basis of my observations the South-Eastern Railway Bill of last session.

The main principle of that Bill was that the Government proposed to guarantee to any Company undertaking the construction of the South Eastern lines interest at the rate of 5½ per cent. per annum on the capital expended, which it was fixed should not exceed £5,000 per mile; and upon the credit of the Government guarantee the Company were to raise the necessary capital. Provision was made that all Crown lands required for railway purposes were to be given to the Company, that no import duties should be charged for any plant, material, rolling-stock, and stores required for the construction of the railways; that no fencing was to be erected along the lines passing through Crown lands until such lands were alienated from the Crown, and that fencing was then to be erected, but the cost to be charged to maintenance and not to construction. It was further provided that the gauge of the line should be 5 feet 3 inches—that the weight of the rails should not be less than 40 lbs. to the yard, and that trains should run along the railway from one end to the other at least once every day.

Still further it was provided that the working expenses and cost of maintenance should be defrayed from the receipts of the lines, the balance to be applied to the liquidation of the 5½ per cent. guarantee payable by the Government. I should have stated that the sum of £5,000 per mile did not include a line of telegraph, which would have had to be constructed and worked at the cost of the Government. Such were the principal provisions of this wonderful Bill. No one but an engineer or a man practically conversant with railway matters can appreciate in any wise the immense powers sought to be conferred by this Bill on the Company who were its real promoters. It does infinite credit to the representative of the Company who prepared it for the draftsman, and he will have the satisfaction of knowing that although the Bill did not pass it will yet carry with it into the deep obscurity of the archives of the province the indelible stamp of his genius. There was no specification nor any description whatever of the character of the works to be carried out in the construction of these lines included in or attached to this Bill, but everything great and small was left to an agreement to be subsequently entered into with the Government. This was a most fatal defect in the measure, and one which should have ensured its immediate rejection by the House of Assembly. On this agreement, so slightly treated, everything depended. The formation, width of cuttings and embankments, the class of gradients, the quality and quantity of ballast, description of sleeper, the nature of the bridges and culverts, the style of fencing, and the description of rolling stock; in fact, the whole substantiality of the works throughout depended upon this subsequent agreement which would not come before the Legislature in any shape. The responsibility of making and recommending the agreement to be entered into would doubtless have devolved upon the Engineer-in-Chief, and I submit that this should not have been. The amount proposed to be expended in the South-East by this Bill was £850,000, and I believe I am right in saying that the tremendous power of framing and recommending the agreement referred to in which the omission of a single clause, or the specification of one class of work instead of another, would save the Company tens of thousands of pounds, should not have been left in the hands of any one officer of the Government, however honourable and impartial he might be. The agreement should have been made the subject of Legislative enactment at the same time as the Bill. The nature and

description of the works should have been scheduled and set forth in detail in the Bill itself. There was one provision in this Bill the astuteness of which I feel that I shall never be able sufficiently to admire, and that was that "trains shall run along the railways from one end to the other of the line at least once every day." This arrangement would not strike many people at first sight as being at all peculiar, the wording being a triumph of ingenuity, it simply means that one train need only start from one end on one day, and return from the other end on the next day; consequently, only half the rolling-stock would require to be ordered that would have been necessary had a train run from each end once a day. The Bill provides for one engineer to supervise 170 miles of railway. This provision is so utterly absurd that I have scarcely patience to discuss it. If every thirty or forty miles of railway constructed by the Government with ordinary contractors, requires one Resident Engineer and three or four Inspectors of Works, how immaculate must that Company of contractors be who require only one Resident Engineer and no Inspectors of Works at all over 170 miles of railway. It certainly is a matter of great surprise to me that no voice should have been raised to point out to the late Government the full meaning and effect of the South-Eastern Railway Bill, and that it should have been left to one man, and only one, to set forth and comment upon the provisions of that Bill in the columns of the *Register*, under the *nom de plume* of "Civil Engineer." I understand that to that letter the South-Eastern Railway Bill is largely indebted for the many radical alterations that took place in Committee, and to the consequent delay which resulted in the Bill lapsing altogether.

This South-Eastern Railway Bill was further conspicuous by the absence of any stipulations for the protection of the interests of the Government. There was no provision for taking the works out of the hands of the Company in the event of the lines not being constructed satisfactorily. Power should have been reserved to the Government to terminate the arrangement with the Company for breach of covenant, either with regard to the quality of the materials used or the character of the workmanship that obtained on the construction, the Government simply reimbursing the Company for its outlay on the work that had been passed by the certifying Engineer as satisfactory and in accordance with the specification employed.

A somewhat similar provision should have been made, reserving power to the Government to terminate the contract in the event of the lines not being worked to their satisfaction. A little explanation will show not only the reasonableness, but the extreme necessity of this provision. It must be evident to all who have studied the subject of railway extension in this colony that there is not the slightest probability of any of the projected lines, either in the North or in the South-East, returning a net profit of 5½ per cent. for very many years to come. I think this will be admitted by all who have any knowledge of the matter, and who can view this question fairly and dispassionately. The Government is bound to pay the Company 5½ per cent. whatever the result of the management and working of these lines may be. It will be seen therefore how much interested the Government would be in securing the greatest economy in this respect. It will be remembered that the receipts of the lines are to be applied first to pay the management and working expenses; the net profits to be applied towards liquidating the 5½ per cent. guarantee.

Seeing, however, that there is not the least likelihood of these lines paying 5½ per cent. net profit for many years to come, what

possible inducement have the Company to manage economically the working of the railways. The only interest they can have in the conduct of the traffic and maintenance is so to regulate the management as to pay the working expenses; beyond that the management can be as wasteful and extravagant as the Company please. Everything that has a tendency to increase the revenues of the railway, and lessen the expenses of management and maintenance, directly affect the payment the Government have to make under the guarantee; and most certainly the same thought and attention should be given to the endeavour to make the railway receipts meet the working expenses and interest on capital as though the lines were wholly under Government control. Therefore I submit that power should have been reserved to the Government in this Bill to exercise a close supervision over the management and working expenses of the railways, and to enable them to take action should it appear that the revenue suffered from an unnecessarily costly management consequent upon the carelessness with which a Company, safe in its immunity from loss, were conducting its operations. The guaranteed interest must be met from the public revenue, and the Government therefore would have been completely justified in inserting a provision which would enable them to demand the closest supervision, and every reduction of current expenses which could be safely effected. It is, of course, possible that the lines might be so worked as that it would be neither necessary nor expedient to use this power, but in any case the State would not suffer by having the power.

It appears to me that railways should be carried out in one of two ways, either by capitalists undertaking the construction of railways at their own risk in conformity with the Standing Orders of the province, or else the work should be accomplished by the direct agency of the State. Certainly it is difficult to see what special advantage is to accrue to South Australia through the construction of railways by means of a guaranteed Company. There is no reason to suppose that the Government would not have at least equal facilities in raising directly by means of ordinary loans the money required for railway construction, as it would have in obtaining subscriptions to the capital of a guaranteed Company, while the former system of obtaining the money would leave the Government entirely unfettered in every subsequent process connected with the construction and management of the lines. As a matter of fact, the Government would lose by not raising the money required for railway construction directly by means of ordinary loans and without the intervention of a guaranteed Company. In proof of which I need only refer you to the price-list of Indian Government Securities and guaranteed Railway Stock. The Five Per Cent. Stock of the Secretary of State, the interest of which is payable in London, is generally quoted at £5 to £8 higher than the Five Per Cent. Guaranteed Stock of the Railway Companies, unless in the case of a Company returning greater net receipts than the amount of interest guaranteed. The Indian railways have been largely constructed on the principle of Guaranteed Companies. The proposed guarantee system here, however, differs in some important points from that of India. In India, so far as I have been able to gather, the expenditure has not been restricted to any fixed amount per mile, and the interest has been guaranteed for the total amount expended in the construction. All the drawings, however,

have to be approved by the State Engineers. Further, when the earnings of an Indian railway surpass 5 per cent., one-half the surplus goes to repay the Government the loss on the guarantee until it be defrayed; the other half to the Company. When the loss to the Government is repaid, the whole profits go to the Company. Under the proposed guarantee system in this colony the expenditure was limited to a certain mileage rate, and all profits beyond the 5½ per cent. were to be treated as under the Indian guarantee. In both cases the entire risk and actual loss is borne by the State; the whole profit goes to the Companies, the whole loss to the Government. The South Australian proposed guarantee system is slightly in advance of the Indian system; but the principle is bad under any conditions. Sir John Lawrence, the late Governor-General of India, writing of it, states:—"The experience of 20 years seems to show sufficiently that there is no reason whatever to expect that the Government can derive any financial advantage from the adoption of the system of Guaranteed Companies in supplying the capital required for railways, unless such Companies actually execute railways and work them very considerably cheaper than the Government could through its own agency. My own very decided opinion on this point is that the direct agency of Government would certainly be more economical than that of the Railway Companies, and then there would in almost every respect be advantage to the State financially, and therefore to the community of India at large, if the Government were to determine to carry out railways through its own Engineers with money directly borrowed in the market for the purpose." I am glad to be able to adduce such high authority in support of the views I hold on the guarantee system.

I cannot do better than close this paper by adopting the spirit and in some measure the letter of some general observations of Sir John Lawrence, and applying the same to railway extension in this province. I may state here that I have been assisted very materially in the preparation of the latter portion of his paper by the published minute of Sir John Lawrence on the guarantee system of India:—"An extravagantly constructed railway is permanently a financial failure, and as the needful capital has to be obtained by the State, it follows that an unsuccessful railway is a public burden."

In illustration of this latter statement it is only necessary for me to refer you to the Middleton and Strathalbyn, and the Port Wakefield and Hoyle's Plains Railways. The Middleton and Strathalbyn line is 21 miles long, and has cost about £115,000; the yearly contribution from the revenue for interest is £6,900, whilst the actual returns amount to £1,000, or 0·88 per cent. upon the capital expended. Similarly, the Port Wakefield and Hoyle's Plains Railway (3 feet 6 inches gauge) is 28 miles long, and has cost about £90,000; the yearly contribution from the revenue for interest is £5,760, and the actual returns amount to £150, or 0·15 per cent. upon the capital expended.

Skill in engineering work implies the successful adaptation of the art of construction to varying circumstances. For a poor country like South Australia economy is one of the essential conditions to be complied with, and its requirements may be as rigid as any of those imposed by physical conditions.

"Wholly to reject railways for a country which is not able to support lines of the most costly

description is quite unreasonable, and if on further examination in detail of the probable cost and return of any of the lines which otherwise seem desirable, the expense of lines of the ordinary gauge seems prohibitory, while lines of a narrower gauge would be financially practicable, it would be a most mistaken view to reject the narrow gauge line. If there is one thing which comes out in bolder relief than another in connection with railway construction in all parts of the world it is this, that those lines are financially successful in which the capital accounts are kept down to a low amount, and those are as a rule unsuccessful in which this has not been accomplished. The lesson to be learnt from this is that the character of the line and the amount of expenditure upon it should be regulated as far as possible by a proper consideration of the probable returns, and not more than is essential by any preconceived ideas of what is the best standard form of railway to adopt." The Queensland railways afford a good illustration of these remarks. It would have been the extreme of infatuation if Mr. Fitzgibbon, the Engineer-in-Chief, had attempted the adoption of the English standard form of railway for Queensland. The study of the natural features of the country revealed the fact that the expense of a line of the ordinary gauge would have been absolutely prohibitory, and so Mr. Fitzgibbon wisely decided to adopt a line of the exceptional gauge of 3 feet 6 inches, and took what was then considered a very bold step; and in those days prophets arose in the land, who, with the far-reaching vision of most modern seers, predicted that the whole scheme would be a failure, and that it would be impossible to work the long main range incline, with its ruling gradients of 1 in 50 and its reverse 5 chain curves. These were false prophets, and their voice is no longer heard, but instead there can be heard the shrill whistle of the labouring engine, with its hundred tons of goods and passengers, ascending gradient after gradient—now vanishing into tunnels, or curves of five chains' radius, and anon appearing on some giddy height overlooking the tops of trees in the ravine a thousand feet below. Such are the facts of to-day, and Mr. Fitzgibbon has been thus conclusively proved to have been right in his choice.

It is very mistaken to apply to this colony rules essentially based on the wants of England—England of all countries the richest, the most populous, the most celebrated for its manufactures, the most addicted to commerce, an island of small size in a highly advanced state of civilization, where dispatch is of extreme importance and time equivalent to money—England, of all countries, is the last which we in this colony should take as our model in these things.

"In one respect, certainly, but only in one, can it be admitted that English standards are applicable—let us see that all workmanship is thoroughly good of its kind, and every part of the construction permanent and suited to what is required of it."

It only remains for me now to acknowledge my sense of the obligation I am under to your Excellency and gentlemen for the patient hearing you have given me whilst reading this paper, and to express my hope that the views I have enunciated upon railway extension, and the agency to be employed in the construction of railways, may have been such as to meet with your favour and the general acceptance of those who think at all upon such subjects.

PAPER READ BY DR. SCHOMBURGK, ON TUESDAY, AUGUST 9, 1870.

SUBJECT—"THE INFLUENCE OF FORESTS ON CLIMATE."

"Whether or not forests are of importance to climate is a question pretty freely ventilated of late by science; but how important they are in the household of nature, and how closely connected with them is civilization, I shall endeavour to prove in the course of this evening.

"Several of my remarks were gathered out of a work of Professor Schacht, a German botanist, who, having distinguished himself by his works on botany, died in the prime of manhood, and too soon for science, which lost in him one of its talented disciples.

"Wherever we look we find the produce of the forest; wherever we go we come in contact with it. Our dwellings, furniture, ships, railroads, tools, &c.—our mind could not exist without it, nor could we protect ourselves from the cold of the winter, could not prepare our food, could not use the power of steam to fly across land and sea, if there were not or had not been forests. The climate, sheltered situation, humidity, and fertility of soil depend on them.

"In nature we behold a constant circulation of matter. The plants and trees absorb the carbonic acid generated by breathing or liberated by decomposition, and exhale instead oxygen, and this oxygen is necessary to the breathing of the living creation.

"The green leaves and young branches of trees derive a great deal from the atmosphere by binding the carbon of the carbonic acid for the purpose of producing woody substance, amylo, fibre, &c. Likewise the soil gets the benefit by the dropping of the leaves, which, decomposing, return to it partially the materials taken out of the ground by the roots. But, what is equally important, the leaves also cover the surface when decaying with a rich layer of humus, the shadows of the trees keep the ground moist, and so a constant decomposition takes place.

"Now, we know that water is necessary for the existence of plants, for without water, no diffusion; without diffusion, no vitality. If on one side the forests absorb a great deal of water out of the atmosphere, they also, on the other side, exhale humidity on a large scale. As a rule, humidity surrounds them, rain falls, and dew. In the same manner as the lightning conductor attracts the electric fluid, the forests attract and draw down the rain clouds, which benefit themselves, and likewise the neighbouring agricultural land. We find, therefore, as a consequence, always good agricultural land near forests.

"Without doubt you are all acquainted with the fact that plants are not alone nourished by their roots, but also nourished by their leaves, which are the lungs, and by their inhaling and exhaling purify the air in a great measure. It is perfectly well understood that dew is nothing else than a deposit of mist or vapour on

the surface of the earth, which only can be generated by having been exhaled or evaporated from the surface of the earth; but the dry sand and naked rock cannot exhale any humidity, therefore dew very seldom falls on them, and only in consequence of attraction by a neighbouring forest. The forest itself presenting a very large surface for evaporation returns the loss of the soil in the shape of a refreshing dew, which falls on it in abundance. If we find that very little dew falls on the soil of a very dense forest, the reason is, the rays of the sun cannot penetrate deep enough and convey heat thither, consequently very little evaporation can take place and produce radiation of heat.

"It is perfectly well known that most of the rivers spring from wooded mountains. The forests conserve the water of a country, and thus nourish the rivers and springs. In a desert the rivers generally dry up. All those magnificent and powerful rivers of North America spring from primitive mountainous forests; but I doubt that they will continue to discharge the same quantities of water in the sea for the future when their mother forests are gone. Already we hear that the Mississippi is perceptibly getting lower since the last decennium. We know also that when, during the winter, snow and ice are melting, great bodies of water suddenly gather in the mountains, and come rushing down with disastrous effects. But even here we perceive a great difference in the manner the waters are drained off. For instance, if such a stream springs from a dense forest, a great deal of ice, snow, and water are retained by the layer of humus acting like a sponge, and consequently the water is drained off gently and with much less danger. But when once the forests of a country are gone there is nothing to check the wild impulse of the waters, and very destructive inundations take place. With reference to this, I wish to point out as one instance only the fearful inundation caused every year by the Rhone in France.

"A mountain range, a wall, a forest protects us against the winds, and we have no business to undervalue this protecting power of the forests; for it favours the growing up of young plantations, keeps the neighbouring agriculture in good condition, stops the progress of sand, keeps swamp fevers and ague away, and counteracts the drying effects of some winds, besides affording cooling shade. We note the astonishing fertility of tropical forests. Looking at this, I fancy nobody could reasonably doubt the beneficial influence of forests.

"We have good reasons for presuming that a great many mountains at present naked and denuded of trees were formerly closely timbered. But when they were cut down the layer of humus left behind was protected no

longer, the springs dried up, every violent rain washed some of the good land away, the soil became poor, and the vegetation died away.

"A Government, or public body assuming the direction of a newly-established colony, ought always to make the preservation of forests a first consideration, and to establish protective laws, whereby the forests could be preserved, and be made to yield a handsome revenue to the State at the same time.

"Some countries no doubt at the present time, bearing the character of a hopeless desert, were always so—for instance, the Sahara; but other countries now in a similar plight were formerly in a different condition. All those vast and almost endless savannahs or plains, and prairies of Australand, South Asia, were once heavily timbered. Diodorus of Sicily at least mentions the existence of immense forests destroyed by fire.

"According to Caesar and other Latin authors Germany was covered with immense forests, and according to Herodotus and Thucydides the same was the case with Greece, Italy, Spain, France, and England. If we believe in the testimony of Diodorus, the forests of Spain were devastated to a large extent. We know that this country when subjugated by the Romans was covered with large forests, especially its southern provinces. But at the present time only her coasts retain their forests, and the interior presents the aspect of a vast plain covered with health, lavender, and rosemary.

"The forests of the Peloponnesus were burnt down by Ali Pasha, and in consequence there came famine and drought. Likewise a Russian general in modern time rendered his name infamous for ever by burning and destroying wholesale the forests of the Caucasus for the purpose of routing out and starving the brave Tcherkessians. The name of this man is Dibitch Balkansky. Since the destruction of these forests the climate has changed entirely, the country has become barren, droughts and famine set in, and, in consequence, thousands of these brave people emigrated to seek a new home in Turkey.

"From Denmark, Sweden, and Russia, Germany, North America; in fact, almost from every direction, we hear accounts how forests disappear, how fuel becomes dearer every year, and the re-establishment of forests becomes a question of a very grave aspect, and immediately connected with the welfare of a country.

"A gentleman and scholar knowing his Homer and Horace by heart, and travelling through modern Greece, could never find out the meaning of the famous wine of Moresitis, for its vineyards a long time ago ceased to exist. He nowhere could behold the sacred pine grove of Poscidon. Where are now the

pastures around the sacred castle of Dardanos, on which 3,000 mares used to browse?

"Let us hope that the times are past for ever when the progress of civilization was equal to wasting and desolating the surrounding nature. One thing is certain—a broad strip of waste land follows in the wake of culture, and noxious weeds like henbane, opium, thistles, nettles, &c., serve to mark the footsteps of men. Before him nature in all her beauty, behind him desolation and hopeless waste. Looking at this picture, we have no cause at all to be proud of being called the Lords of Creation; but let us hope that the future generations will be wiser than the past ones.

"If any one still feels inclined to doubt the influence of forests on the climate of a country, I beg to give several instances of modern times. Egypt, well known for its dry climate after the destruction of its forests, olive and other plantations, had about six rainy days every year on an average; but since so many millions of useful trees have again been planted, there are now about 24 rainy days per year recorded.

"There is a man who deserves the greatest esteem from all civilized nations. Napoleon III., with all his faults, has given the world an example, which at least in France will render his name for ever immortal. Convinced of the great benefit the barren and swampy districts of France would derive if planted with trees, by his command many millions of trees have been planted in such districts of his empire. By his command thousands of acres of the desert in Algiers have been transformed into forests, with trees suitable to the climate, and with surprising results. The Government of Victoria provided him alone for this purpose with $\frac{1}{2}$ cwt. of seeds of the *Acacia mollissina*, 2 cwt. of *Acacia tophanta*, 20 lbs. of gum, and 20 lbs. of sheoak seed, and Messrs. Law and Somner, seedsmen in Melbourne, with about 2 cwt. more of the above seeds.

"By the last accounts, these plantations, especially of Australian species, have already reached the height of 9 to 12 feet, and with their rapid growth a great change of the climate is observable, and twice more rain and dew has fallen in the neighbourhood of these young forests than before.

"By his command, more than 16 geographical square miles of the swampy and unhealthy country along the coast of the Bay of Biscay, in the department of Landes, where swamp fever was prevailing, have been planted with millions of trees, especially the cork-oak and swamp pine (*Pinus maritima*), with a surprising beneficial result. Not alone that these trees have drained the land, but have changed it into a healthy country and fine forests.

"Mr. Chairman and Gentlemen, I think there is not a more staunch advocate for the liberty of nations than I am; but I am also con-

vinced that despotism is, in such respects, highly conducive to the welfare of a nation.

"In Japan a law exists that whoever cuts down a tree is obliged to plant another instead. In Biscay every proprietor plants two for one which he cuts down, and the law compelling them is severely executed. Now, if I had the power, I would even go further, and would compel them to plant three instead of one or two.

"By an ancient law of some nations, he forfeited his hand who cut down a tree without permission of the owner.

"The motion of one of our legislators—I think Mr. Wentzel—to lay out in every new hundred reserves for tree plantations, and the protection of such, is entitled to the thanks of the community; and I hope this motion will receive such support from the House as it deserves.

"Our neighbours in Victoria, convinced of the necessity of such a measure for the well-being of the country, have already begun to carry out this scheme; and in order to promote it in regard to forests, have not alone called to life a Board of Forests, but have also appointed an Inspector of Forests, and under his direction the preservation of forests and young plantations will be secured.

"Truly the desolation, the waste, and destruction of our forests have been so general that it now renders it imperatively necessary to take some effectual remedy against the repetition. It is more than probable that very little timber will be left, and the rising generation will feel this calamity, and cannot but occasion some uneasiness in the mind of those who wish well for their country.

"It is a fact that very few persons have turned their attention to the planting of forest trees on their land. Nothing is more neglected in husbandry than this branch, notwithstanding that on every property will be found some vacant and useless land for other agricultural purposes. Why not plant such spots with forest trees? Most people will shrink back because they will not enjoy the fruits of their labour; but they forget that their children will.

"I cannot omit to mention here an anecdote which I read the other day in an old book on the same subject:—'When Ulysses, after a ten years' absence, was returning from Troy, and coming home, he found his aged father in the field planting trees. He asked him why, being now so far advanced in years, he would put himself to the fatigue and labour of planting that he was never likely to enjoy the fruits. The good old man, taking his son for a stranger, gently replied, I plant for my son, Ulysses, when he comes home.'

"Mr. Hare, in an able paper read before the Philosophical Society the other day, advocated the planting of trees. A gentleman in the *Register*, under the name of 'Buffalo Row,' published a very sensible letter on this subject (I am astonished that this gentleman did not come

before the public with his real name). The Editor of the *Comet* pleaded for the same cause. And I have commented on the same subject in all my annual reports—the advisability to plant on the vacant land—beside our railways and public roads—trees.

"In the early days of the colony, a great oversight has been made by the Government in not laying out in every hundred reserves containing, say about one or two square miles for the purpose of forest plantations. In omitting this, I consider it one of the greatest mistakes made.

"I am sure some of you who have visited France and Germany must have been struck by the pleasing effect in seeing the railroads and public roads lined with ornamental and useful trees. It would be unreasonable to expect that in our young colony this should already have been carried out; but I may say the time has arrived when our earnest attention should be directed to the planting of trees in all suitable public places.

"I fear we have let slip a very favourable opportunity this season to begin this scheme, and I can only regret that half of the unemployed, trenching at the New Lunatic Asylum and Orphanage at Magill, have not been set to work, say at the Port line, to trench the vacant land, and plant it with useful timber trees—such a belt of trees, as the Editor of the *Comet* remarks, may be utilized in the future as sleepers for the railways.

"I am sorry to say our peculiar climate, especially the plains, is not very favourable for the growth of the noble forest trees of Europe and North America; but I am convinced there are a good many kinds of pines, especially the Californian ones, which grow most luxuriantly with us. There are a good many kinds of gum trees from Western Australia, as the famous jarrah or mahogany (*Eucalyptus marginata*) and the splendid red gum (*Eucalyptus calophylla*), whose luxuriant growth with us is undeniable, and their timber the most valuable in Australia.

"As a proof also of the beauty of those trees, I call the attention of the visitors to the Botanic Garden to such a one. It is standing near the cockatoo cage; it is about seven years old, and stands in untrenched ground. I was so fortunate as to raise thousands of such noble trees from seeds, and will be able to give numbers away for the above laudable purpose.

"But not alone these two named trees; no, also the red cedar of New South Wales, whose valuable timber we import in large quantities, could be raised for the purpose.

"Naturally the present generation would not derive a benefit from such a scheme; we would only have the pleasure to watch their growth, and the pleasing sight of the green belts traversing our plains, denuded at present of all trees; but I am sure the next generation would bless us for such an important undertaking."

SUBJECT—"LIGHT RAILWAY CONSTRUCTION."

I propose in this paper to discuss the two questions—1st. Whether it is possible to construct railways over moderately easy country, at a cost not greatly exceeding that of a common road? and 2nd. Whether such cheaply constructed lines, traversing districts of very limited population, and with but a small amount of traffic, can be worked in such a manner as to pay interest upon capital invested in them, over and above working expenses, at freight and fares below the cost of transit upon ordinary roads? If these two questions can be answered in the affirmative, I think an important step will have been gained by the advocates of railway extension in new and thinly populated countries.

In the course of this paper I shall have frequently to refer to Mr. Patterson's paper upon "Light Railways" lately read before this Society; and I am happy to be able to say that I hail both that gentleman and his opponent, Mr. Boothby, as railway reformers, having the same object in view as myself, viz., the modification of the railway system so as to adapt it to the circumstances and requirements of a country in which the conditions as to population and traffic are materially different from those of the thickly populated countries of Europe. I shall have to differ, upon some points, from both of these gentlemen, but I hope that I shall not find it necessary to be so severe upon either of them as they have been upon each other.

I fully agree with Mr. Patterson as to the great importance, I may say necessity, of a thorough and complete examination and survey of any line of country over which a projected line of railway is to pass; and I concur also in the views of that gentleman as to the expediency of a liberal expenditure upon earthworks, wherever necessary to insure easy gradients, so as to reduce the weight of engine required to draw a given gross load.

If lines of small traffic are to pay, it is obvious that the construction cost must be kept low, otherwise the mere interest upon capital may amount to more than the gross receipts. Assuming the projected Port Augusta or South Eastern line to have a traffic of 30,000 tons per annum, the difference in the interest between a line constructed at a cost of £2,500 per mile and one costing £4,000 will be £18,000 per annum, amounting to an average charge of twelve shillings upon every ton of goods carried. With a traffic of 150,000 tons per annum, this charge would be reduced to two shillings and fivepence per ton, and with every increase of traffic would become less and less. It is, then, evident that if the fares and freights are to be kept within reasonable limits, the construction cost of lines of small traffic must be kept as low as is consistent with economical working. How low this may be, in certain cases, we shall have

to consider in a subsequent part of this paper. If a line opened with a small amount of traffic should, in the course of a few years, have a considerable increase, a more expensive kind of permanent way, and more expensive rolling-stock may, perhaps, be afforded if such should be thought expedient. Upon this point I quote the following remarks upon American lines of small traffic, in an excellent article upon the Indian Railways in the *Westminster Review* for July, 1869:—"When planning a railway, they (the Americans) first ask what are the actual wants of the district to be traversed, and if its traffic seems too small to pay for costly and substantial appliances, only cheap and slight ones are provided, timber, perhaps, being substituted wholly or to a great extent for iron, and proportionate parsimony observed in all other arrangements. In the Adiconrack district of the State of New York, a railway lately made entirely of wood is being worked satisfactorily and with profit to its owners. According to the description it is but a homespun affair. A good deal of rough trestle work, consisting of cross logs is used, and into the sleepers, which are not squared at all, the rails which are of maple, are set in heavy notches and tightly wedged down by small wedges made of the waste of the rail. In some places the gradients are as much as 70 feet to the mile, one in seventy-five. But rough as the whole contrivance is, it serves its purpose for the nonce, far better than any expensive elaboration would. Its cost per mile was only a tenth part of that of a first-class iron road, and rates and fares can therefore be fixed proportionately low, and at sums which the infant traffic can afford to pay. Very possibly in eight or ten years, rails, sleepers, and all the rest of the materials may be worn out and require complete renewal, but by that time the traffic, thanks to railway fostering, may have expanded into dimensions requiring and able to pay for improved means of conveyance. The creators of the wooden railway may then be encouraged to replace it by one of iron, with full assurance of obtaining as high a rate of profits on the larger outlay as they had already received on the smaller; whereas, if a first-class railway had been made in the first instance, not only would the greater part of the capital have been lying unremunerative during the interval, but the traffic of the district would have remained undeveloped from inability to pay for the expensive railway assistance which alone was available for its development. Whether India would have done well to act from the beginning on the modest American plan is a matter which we will not now stop to discuss. Let bygones be bygones. What has been done is done, and cannot now be undone. But with regard to the future the American example does certainly

seem deserving of imitation in some of those more thinly peopled and poorer districts into which it is proposed that the Indian railway system should be extended." Captain Galton, in his report to the British Board of Trade more than a dozen years ago, expressed himself much to the same effect:—"In a new country, where time is not so valuable, high speeds are not required, but a cheap and certain means of locomotion for all classes, and of transporting the produce to a market is a first necessity. A railway is the best instrument for satisfying this want. Any saving in the cost per mile of a railway adds to the means available for extension, and in a rapidly developing new country capital is dear. Hence a rough-and-ready cheap railway, although it entails increased cost for maintenance, is preferable to a more finished and expensive line. These considerations have influenced the construction of American railways, and the system which has grown up under them is well adapted to the wants of the country."

* * * * "In making railways in a new country, bearing in mind the high rate of interest which money commands, the outlay for construction should be as small as possible consistent with safety and economy of working, the object being to devote the money to be spent to extending the mileage and opening out the country, rather than to making very solid works or to obtaining very high speeds." * * * * "But it is with reference to the construction of railways in our own colonies that the American system deserves special notice. The considerations which led to the adoption of, and the necessities which fostered that system apply with equal force to railways in the colonies."—*Captain Galton's Report.*

In connection with these expressed opinions of Captain Galton, and of the *Westminster Review* in favour of cheap railways for lines of small traffic, I quote the following passage from a letter upon the principles of construction applicable to new and thinly peopled countries published in the *South Australian Register* of October 5, 1857; although I am happy to be able to say that the allusions to our Legislature now require considerable modification:—"At the present juncture it is of the utmost importance to the onward progress of the country that just views should be entertained upon the railway question. Certain hon. members of the Assembly in abandoning the tramway delusion have decidedly made one step in the right direction; but though they have freed themselves from that one delusion, they would seem to be still labouring under another, fraught with a yet greater amount of danger to the future interests of this Province, viz.—that railways upon which steam power is employed must necessarily be immensely expensive both in

original construction and in the subsequent working. Hence, many of the gentlemen who formerly belonged to the tramway faction, had but little hesitation in voting £180,000 for the mere construction of 21 miles of railway, without rolling-stock, over a comparatively easy line of country, under the erroneous impression that it would be unreasonable to expect that any railway upon which locomotive engines are to be run can be constructed for less than from £8,000 to £9,000 per mile. In vain have I pointed out the fact that the average cost of the American lines (up to the year 1857) amounts to only about £7,000 per mile, although some portions, where there were engineering difficulties, cost as much as £28,000 per mile, and that several of the easier lines cost only from £1,500 to £2,000 per mile, and some even still less—that, as well in densely peopled Belgium under extremely low fares, as in sparsely peopled America under equally low fares, the railway system has been actually reproductive; while in England, under a rate of fares about three times as high as either in Belgium or in the United States, the railways have scarcely paid 3 (three) per cent. interest to the shareholders. In vain have I endeavoured to show that what has been done may be done again, and that the comparative failure in England must be looked for in something extraneous to the railway system itself. The prevalent impression still appears to be, that because labour and imported materials are dearer and population less dense in a new country than in England, and the fares there high and interest on the capital invested but small, therefore here the fares must be nearly double what they are in England, and that even then railways cannot be expected to pay interest at all upon the capital invested in them. May we not, however, rather and with more reason entertain some slight suspicion that there is something faulty in the English system even when applied to a densely populated and wealthy country, and that to a thinly populated country with a comparatively small amount of traffic, it is still less applicable?"

I place side by side with the above some extracts from Mr. Patterson's paper, to show you to what extent that gentleman approximates to the views therein set forth as to the possibility of low construction cost in connection with steam-power traction. In the present case there cannot be the slightest suspicion of either party having merely adopted the views of the other. It is, however, but just to remark that Mr. Patterson's approximate estimate of £3,540 per mile for a 3 feet 6 inch gauge line from Port Augusta northwards is based upon Mr. Wallace's estimate of £4,000 per mile for a line of 5 feet 3 inch gauge.

Extracts from Mr. Patterson's Paper on Light Railway Construction.—"The subject of Light Railway Construction is one that is not only exciting the deepest interest in Europe and calling forth grave discussion there, but it is also one of very great importance to these colonies, and at this time to this colony in particular, and its importance is, I am glad to say, fully recognized by the people and Legislature of this province." * * * "It appears therefore, that a 3 feet 6 inch gauge railway for the proposed line 200 miles north of Port Augusta would cost £3,540 per mile, and that amount does not include either fencing or a line of telegraph. It is presumed that fencing will not be required in the desert, and if the line is ever constructed it will be able to use the overland telegraph to Port Darwin about to be made in connection with the Telegraph Maintenance and Construction Company. As Mr. Wallace's estimate of £4,000 per mile must have included the expenses of the English Directory, as well as the more costly local directorate and many

other expenses which are inevitable in connection with a guaranteed company, I think it very possible that this line could be carried out largely within his estimate of £4,000 on the 5 feet 3 inch gauge by the Government, and consequently the line of 3 feet 6 inch gauge could be carried out for a corresponding less amount than the sum I have placed down for it, supposing it to be undertaken by the Government."

It will be noticed that, in the above-quoted paragraph from the *Register*, I ventured thirteen years ago to broach the highly heterodox doctrine that, possibly, the English system of railway construction might not be quite the quintessence of perfection even when applied to a densely populated and wealthy country. I have since had abundant reason for adopting that doctrine as an article of faith. The doubt expressed as to the absolute perfection of the English system it will be observed runs through the following passages from the same letter:—"In a country where fuel is expensive it is of the first importance to strike a just balance between the interest of money necessary to obtain easy gradients and the increased cost of working severe gradients. The shortest line with workable gradients would not in all probability be the best line that could be adopted in any case. A gradient of 1 in 37 (like that on the Birmingham and Gloucester line), or even a gradient of 1 in 20, is a workable gradient; but neither these, nor a gradient of 1 in 60, can ever be an economically workable gradient in any country where the cost of fuel is an item of any importance in the sum total of the working expenses. Before any such objectionable gradients are adopted, a careful comparison ought to be instituted between the interest upon any additional amount that it would be necessary to borrow in order to obtain easier gradients, and the saving that would be effected in locomotive power. The days are, I hope, for ever gone by when an 'eminent engineer' could answer, 'It would not make much difference—a little more whip-cord would do it'; though, perhaps, even in the present day some might be found to answer, 'A little more steam would do it,' but a little more steam involves a little more fuel, and a little more weight of engine, and we ought to be informed exactly how much more, and how much it would cost."

Extract from Mr. Patterson's Paper.—"I am afraid there is a great tendency in these days of mechanical improvements in the locomotive to make light of steep gradients. It is true that the experience of late years has proved that gradients and curves which were once deemed prohibitory are now workable with facility; but it is none the less true that heavy gradients demand an increased weight of engine and a proportionately heavier road, and entail serious additions to the cost of working. Three or four gradients of 1 in 50 on a line of easy gradients otherwise, are quite sufficient to completely alter the type and weight of locomotive that would else have sufficed to work the traffic of the line. If I were in charge of any of the surveys of the proposed new lines, and found that I could obtain ruling gradients of 1 in 100 with few exceptions, I would feel inclined to largely sacrifice the cost of construction at those points in order to keep down the weight and power of locomotives required, and to save the future working expenses of the line."

"The permanent way being the least permanent part of a railway, is that part of the construction where the greatest saving may be effected in the first instance, without detriment to the line in future. Were I employed to construct a railway from Adelaide to Willunga, and limited to an outlay of £5,000 per mile, I would prefer expending £4,500 per mile (if necessary)

upon the grading, and constructing the most makeshift kind of American permanent way with the remaining £500, and adapting the rolling-stock to it, and making broad palings watch-boxes serve for temporary stations, rather than adopt inferior gradients with an expensive kind of permanent way with heavy engines and heavy rolling-stock—the present orthodox mode of construction with the majority of English engineers. The permanent way, under ordinary circumstances, requires frequent renewal. The heaviest iron rails oxidize at the rate of about one per cent. annually, and with heavy engines and rolling-stock are frequently crushed, abraded, and bent, and require renewal sometimes a few days after they have been laid down; while timber, which enters so largely into nearly all the American constructions, if prepared by the preservative processes now well understood, is rendered unsusceptible of atmospheric influences, and if only subjected to strains in proportion to its strength is, in reality, more durable than iron; while a railway constructed principally or wholly of timber is more easy and pleasant to travel upon, and causes considerably less wear and tear of machinery and rolling-stock. The engines and other rolling-stock ought always to be adapted to the line upon which they are to run, and also to the amount and nature of the traffic, as well as to the kind of fuel most easily and cheaply to be obtained. Heavy engines of the long boiler construction, resting upon eight or even six wheels with fixed parallel axles, are obviously unsuitable for lines upon which it has been found expedient to adopt sharp curves, however substantially such lines may be constructed; and engines with fire-boxes constructed for the combustion of coke, it is equally obvious are not the most economical for localities where coke fuel costs four times as much as the quantity of wood fuel required to produce the same effect. Heavy rolling-stock, resting upon but few points of support (of doubtful expediency in any case), it is also evident, must produce a considerable amount of damage and derangement upon slightly-constructed lines, whether such lines be composed principally of timber or of iron. The strength of the way and the weight of the rolling-stock ought always to bear a due relation to each other. The less the break of continuity at the junctions of the rails, the greater the speed obtainable with a given amount of wear and tear; hence a line with the rails connected by Adams's patent fished joints could be worked at a given velocity with less wear and tear than one laid in the ordinary way—that is, ordinary way in England; for from Captain Galton's report it appears that the fished joint, or at least a modification of it, is common upon American lines where iron rails are used."

In confirmation of the opinions above expressed as to the inexpediency of the expensive and heavy system even for lines of very large traffic, I quote the following more recent opinions as expressed in leading articles of the principal scientific journals, and of the *London Times-Engineering* of August 28, 1868, has the following:—"The purely locomotive engineer is not so apt to see these merits (i.e., of the double bogie engine) as is the civil engineer, and especially the permanent way engineer. The former looks upon the permanent way as a camel's back fitted to bear any and all burdens—burdens which no final straw can break. But just as the strength of a chain is the strength of its weakest part, so is the greatest load per wheel of a train the measure of the necessary strength of the permanent way. It must be twice as strong to bear six tons on a wheel as would be necessary for three tons—earthwork, ballasting, sleepers, chairs, and rails—every-

thing must be twice as strong. And so it must be if but two or four wheels of all that are in a train press with a force of six tons each, and the hundred or two hundred others are loaded only to half that weight. The line must be made for the maximum, not for the average nor the minimum, load per wheel; just as the Board of Trade officers will pass a bridge only when it has been tested with the greatest load that, in their opinion, can possibly come upon it, even although the ordinary load be but half as much."

"There will be plenty to deny, and that under the influence of sheer habit, that the permanent way could be made lighter than now, even were the heaviest engine weights but three tons per wheel. Common sense, however, teaches better than this, and even a lawyer, doctor, clergyman, or plain farmer might safely contradict the most eminent engineer who would presume to tell him so—if, indeed, a really eminent engineer had such presumption. The wear or abrasion of the head of the rail is not, it is true, dependent merely (although it is to some extent) upon the maximum load per wheel, and probably two wheels loaded to three tons each will cause nearly as much superficial wear as one loaded to six tons, although they will knock the way to pieces to a far less extent."

"Others will say that inasmuch as our lines are laid for weights of from six to eight tons per engine wheel, it is too late now to consider the question of light permanent way. So it is, yet our existing permanent way would, indisputably, be maintained in better condition with less platelayers' labour, were our maximum weights but three or four tons per wheel. We fully agree with many who would not listen to any reduction in the strength of the way unless in the face of the strongest pecuniary reasons; but it requires no argument to prove that with the present standard of strength the line could be more easily and cheaply maintained in first rate condition, were the greatest weights no more than three or four tons per wheel. Even our present strongly laid lines—and steel rails have long since become a necessity rather than a mere advantage on many railways, such as those in and near the metropolis—are horribly overworked with our present engines, some of them having eight tons on a wheel." * * * *

"In proportion as our railways have grown into vast systems, several of them now working each more than 1,200 miles of line, so has the difficulty increased in respect of any radical changes in the rolling-stock. There is an objection to anything like experimenting so long as it can be avoided, and, of course, if we are to go on for ever in the old jog-trot fashion, along the hard beaten, if not macadamised path of routine, we shall never need to experiment at all. It may be too, not unnaturally perhaps, that a certain class of engineers holding appointments do not care to take up the ideas of outsiders. It might seem to afford room for reflections upon their own qualifications were they to do so. They are supposed to know their business. Why, then, be taught by others? But the necessities of traffic, rather than the likes or dislikes of locomotive superintendents, must yet compel the adoption of something like the double bogie locomotive."

The *Railway News* of May 2, 1868, has the following:—"Another point, and it is one upon which Mr. Fairlie, whose letter to the *Times* we reprint elsewhere, very properly insists, is the immense weight of the rolling-stock at present in use, and the disproportion which it bears to the paying load in passengers carried. The paper lately read by Mr. Fairlie before the Society of Arts enters very fully into this question, and has already produced a considerable impression in the railway world. First, with regard to the engines generally in use, there

can be no doubt that their weight might be considerably reduced with great advantage, for in many cases the unscientific arrangement of their parts necessitates useless additional weight for the purpose of procuring the proper amount of adhesion between wheel and rail. The non-paying load of the enormous tenders attached to express engines might be considerably lessened, and the weight of a portion, at least, of the water carried be brought to bear upon the driving wheels. As to the carriages, the failings of the present mode of construction are even more patent. The Metropolitan Railway is one of the most marked instances which can be taken to illustrate these. The trains on this line are mostly composed of five carriages weighing about 16 tons each, and one locomotive weighing 42 tons, together 122 tons. Thus we have 122 tons of train weight to carry an average of 55 passengers, which at 14 to 1 ton is under 4 tons, being only 1 ton of paying load to 30 tons of dead weight. And this disproportion between the amount of transport of passengers and the powers and capacities of trains employed in effecting it exists to a greater or less extent on all the railways of the country, and involves a loss, which of itself, if remedied, would go far to render undertakings profitable which are now in difficulties. A comparison of a railway carriage with an omnibus admirably illustrates this position. The latter, which has to travel over an infinitely worse road than any line, weighs about 1 ton, whilst it carries 28 passengers or 2 tons, and if the horses be included and every allowance made, the proportion will remain of 1 ton of paying load to 1 ton of material employed to convey it. This is a matter which really deserves the serious attention of directors and managers; for though railway carriages will always have to be more strongly constructed than street vehicles, there need not be such an immense disproportion between the weights of the two descriptions of conveyances." * * * *

"The matters to which Mr. Fairlie directs attention deserve the serious consideration of our railway managers. The time has gone by when stereotyped modes of working railways are to be endured, simply on the ground that they are consecrated by age and proved by experience. Railway property has got into a bad position, and it should be the wish of railway directors and managers to endeavour to find the means of making them remunerative. They cannot now recall the money wasted in litigation, and costly works, and ridiculous extensions; but they may practically effect the same object by reducing, as far as possible, the cost of working, and adopting everything which, on enquiry and careful examination, shall prove to be conducive to greater economy and efficiency. The suggestions of Mr. Fairlie are of this class, and we hope that they will receive due attention in the proper quarters."

Again, the city article of the *Times*, April 27, 1868, has the following to the same effect:—"Annexed is another letter on the subject of wasteful railway management, especially with reference to the heavy and destructive character of ordinary rolling-stock, a point on which many persons hold strong opinions, pertinaciously resisted by some of the authorities most conversant with or accustomed to the existing routine. Unfortunately, the matter can only be fully tested by actual experiment, and as changes of the revolutionary character advocated cannot be made without expense, each company naturally hesitates to be the first to venture. If all the railways of the kingdom were working as a federation, recognizing only mutual interests, every desirable innovation could from time to time be tried on some short

selected line at the common expense; and with the assistance of all; but although some approach to such a state of harmony has been initiated, there are yet too many symptoms that the old spirit of eager antagonism, not only of Boards, but of the shareholders of different lines, is far from wholly quelled, to admit of any sanguine belief that even the misfortunes thus far encountered will prove effectual for its complete fulfilment."

The following is from an article in the *Times* of February 22, 1869:—"Increasing traffic in goods and passengers still continued to demand power and speed, so that light engines grew into heavy ones, and the 35lb. rails grew into 60lb. rails, and the carriages and wagons of the trains increased in proportion. Still the cry was for more, and a contest began like that of the guns and armour-plates of the present day—a contest which is still going on in pursuit of indestructible materials. The Staffordshire iron failed in density, and the wheel tires were squeezed out under the loads like baker's dough or glazier's putty, and dense low moor iron was substituted for it. Then the rails began to yield to the tires and crush out in turn. One thing did not give way and that was the steam. By one process or another the power of the engines continued to increase whatever the duty got out of them might amount to. When the wheel had got the best of it, experiments of many kinds were made how to construct rails with hard outsides and tough interiors, and those who watched them at work could see how the hard iron crumbled away in granules under the loads. The 60lbs. per yard grew up to 84, and culminated at 92, after some hesitation at 75."

"The tires failed again, and iron was given up for steel, first produced by Krupp, and gradually imitated by others. Not long after this it was found that steel rails were needed to resist the hard tires and heavy loads, and Mr. Bessemer supplied the want. Whether the steel tires and steel rails will set up a mutual indestructibility is as yet a moot point. Steel-headed rails and rails with tables converted into steel failed before Bessemer came into the market, and what can come after Bessemer no man can say."

"How fast the destructive course is increasing upon us may be judged from one circumstance. Time was that it was customary to kyanize, or burnetize, or creosote the timber sleepers to prevent chemical destruction or rotting in the ground. Many companies have now given up the practice because the sleepers are worn out mechanically before they begin to rot. In other words the increased momentum, and speed, and increased weight of engines and trains drive the iron chairs into the sleepers and split them, so that they will no longer hold the chair fastenings."

The *Practical Mechanic's Journal* of August 1, 1868, in speaking of the method of making railways with steep gradients and sharp curves in order to save in construction cost, goes on to say:—"The limit, however, to this method was reached when the ordinary type of engine became so heavy on the usual six wheels as to be found so destructive to the permanent way, that rails even of steel, were found to last in some places but a few months."

The *Mechanic's Magazine* of January 10, 1868, says:—"Owing to causes into which it is unnecessary here to enter, our railways have, during the past year, attained a most unenviable notoriety. The financial condition of many of them is at the present moment truly pitiable, whilst the whole system is in a most questionable position. Had it not been for Government intervention during the year just closed, some lines would doubtless have yielded to the

pressure under which they laboured. How much longer some few others will be able to hold their own it is impossible to say. In fact the commercial attitude of numerous lines just now is by no means calculated to inspire confidence in this class of securities, nor to encourage the development of the railway system in quarters still open to the improvement it ever carries with it." * * * *

"One of the leading causes of railway depreciation is that heavy item of expenditure—maintenance of way and rolling stock. This item stands out with unpleasant prominence in every railway account, and although the means by which it might be reduced are, and have been for long past, really within reach, there is no sign of decrease but rather the reverse. And it comes about in a very simple way; trains are run at excessive speeds with engines unnecessarily heavy for the work they have to perform. Of course we must have high speeds for some purposes; we need not knock off our express trains, but they can be drawn by engines of lighter build than we are now using, and fifty or sixty miles an hour will be as readily attained. The destruction to rails and rolling stock is as the square of the velocity, and this destruction, the bugbear of all railway accounts, would be greatly reduced by the use of lighter engines, that is of engines in which the wheels are not overweighted." Similarly and to the same effect the *Engineer* of Jan. 11, 1867, says:—"The greater the load we place upon a railway wheel, the greater the injury done to the permanent way. Not the rails alone, but the chairs and sleepers suffer from the rolling impact of heavily loaded wheels. The longer the wheel base, the more is the evil augmented. All this is an old story, on which we need not dwell, but why should not the story narrate truthfully what is now, as well as what is past? When the engineer finds his bearings heating and cutting, notwithstanding that they are well lubricated, he knows that the surface is too small. Our rails cut and wear for precisely the same reason—the bearing surface is too small, and it does really appear that here Mr. Fairlie has shown us the way out of a great practical difficulty. The only available method of increasing the bearing area of wheel and rail is to increase the number of wheels."

I think that the case for the prosecution in the important cause—"Light v. Heavy rolling stock," may now be considered as nearly closed; I will, however, with your permission call one more witness, viz., Mr. R. F. Fairlie, who in the paper before referred to, read before the Society of Arts, says, speaking of the Metropolitan Railway: "The carriages have very long wheel bases, consequently they offer great resistance to the tractive force of the engine, besides being very injurious to the rails rounding the curves."

"The engines have 32 tons on four wheels, or 16 tons per pair. We have only to imagine this enormous weight, ploughing along at 30 miles an hour to form some idea of the destructive effect, not only to the rails, but to the sub-structure and the machines, the effect being destructive alike to all. No wonder that the line has, as it is stated, been relaid in many places three times with steel rails since it opened five years ago. Not content with this rate of destruction to road and stock, the Metropolitan Company are now receiving, or about to receive, locomotive engines of a still more destructive character to work the St. John's-wood branch, weighing 45 tons on six wheels, with a wheelbase of 14 feet. The only approach to a saving feature in the 42 ton engines—viz., carrying the leading end of the engine on a bissel truck with four wheels—is in these new engines omitted. The bissel arrangement does to some extent

reduce the enormous friction of the engines on rounding the curves, notwithstanding which the grating and grinding noise of the wheels can be heard at a considerable distance. The spirit of rivalry between armour plates and guns is reproduced in steel rails and locomotive engines, with this difference, that the armour plates can be made to withstand the power of the heaviest guns, whilst steel rails cannot withstand the battering of these 45 ton steam hammer locomotive engines."

I think that I have now brought evidence enough against the heavy rolling-stock system, and the question naturally arises—Can the light rolling-stock system be advantageously substituted for it, if not upon lines of very heavy traffic, at all events upon lines through districts in newly settled countries that are facetiously said to have neither population nor traffic, but in which it may be supposed that both will be induced by the facilities for transit which a railway affords? The pith of the whole matter seems to me to be contained in the following passage of Mr. Patterson's paper:—"Mr. Pihl, writing of the Dramen line, states that—'It has two small locomotives with a weight of only eight tons on driving wheels, or two tons on each wheel—that is, not more than the weight of a loaded wagon. These engines have been placed on the line to work the light passenger trains, for which they have proved themselves exceedingly adapted, and also as experimental engines for lines of the smallest amount of traffic, justifying railways as the medium of transport in place of common roads.' The principle which Mr. Pihl proposes for such lines is, that in place of the locomotive being the standard from which the structure has to be proportioned, he takes the weight of a loaded wagon, and the permanent way he proposes to lay with rails of 30lbs. to the yard. There is no doubt that this principle can be carried into effect where lines have to be made through thinly peopled districts, having a very limited amount of traffic."

It is alleged against the light system that light and cheap railways "eat themselves up" very rapidly; and it is an axiom with engineers that the more liberal the original outlay the less are the working expenses; nevertheless it is a most remarkable fact in the history of railway engineering, however paradoxical it may appear, that the greater the original cost of construction, the greater generally has been the cost of maintenance and the greater the sum total of the working expenses. A certain railway in America, of which I shall have more to say presently, cost only £1,616 per mile, the cost of the permanent way having been no more than £524 18s. 5d. per mile. The gross receipts upon this railway (the tariff of charges being, as on all American lines, low) amounted only to £444 per mile per annum, the working expenses being £294 per mile per annum. Now let us contrast this with our own City and Port line, built and worked upon the costly and heavy system. It cost about £30,000 a mile; its gross receipts under our very high tariff of charges amounted to (I think) £2,658 per mile per annum, and the cost of maintenance of way alone during the very first year of its working was no less than £564 per mile, i.e., £120 more than the gross receipts upon the cheap American railway; thus we see that if the very cheap American railway had cost as much for maintenance as our line built after the most approved models of the heavy and expensive type, it would have been worked at a considerable loss, instead of paying as it did, nine per cent. interest upon capital. You will observe that the maintenance of way alone upon our City and Port line amounted to £270 per mile per annum more than the total working expenses of the very cheap American line (£294 per mile per annum.) This was the average of the first four

years from the opening of the line in 1834. Ten years afterwards, in the year 1844, there was published an account of another cheap American railway noticed as follows in the *British Almanack*:—"The Central Railroad consisted of a single line of rails, with turnouts at intervals. The rails are laid upon continuous bearings, and the whole work is of a much more superficial character than would be considered proper in this country (England). To this end the nature of the climate is favourable, it not being necessary to protect the foundations from frost. Considerable apprehensions were expressed lest the stability and strength of the ways and bearings thus formed should prove insufficient; but after an experience of two years it has been found that the amount of damage or derangement has been unusually small, while the slight repairs that have been needed have been performed at a trifling expense, by reason of the facility with which every part can be reached. The cost of the line has by this method of construction been extremely small, viz., for 193 miles, 2,300,008 dollars, or rather under £2,500 per mile." Recently in Westphalia a very cheap railway has been constructed, of which a notice appeared in the *Register* in June 1869. The cost of the line itself was only £1,500 per mile, or including rolling-stock £1,800. The gross receipts are only £229 per mile per annum, and the working expenses the very small amount of £109 per mile per annum, and yet this line pays six per cent. to the proprietors. Maintenance of way, £33 per mile per annum. The line is 12½ miles long, and the traffic upwards of 30,000 tons of goods per annum. From these examples it would appear that a cheap line does not necessarily "entail increased cost for maintenance," but that on the contrary a light and cheap railway, if the wheels are not overweighted for the strength of the line, is considerably less costly to maintain than a heavy and expensive one where they are overweighted, as they invariably appear to be, even when steel rails are employed, under the heavy system."

The cheap American railway to which I have referred as having been completed, inclusive of rolling-stock, for the very small sum of £1,616 per mile deserves more than a passing remark. It is in reality one of the most remarkable lines ever constructed. If any English engineer of the present day were to construct a railway parallel to the Great Western from London to Bristol for such a low sum as £1,616 per mile, and were to realize between eight and nine per cent. profits from the working of the line with a passenger traffic of only 34,000 per annum, and a considerably less amount of goods traffic, I think few here present this evening would refuse to subscribe something towards erecting a monument to his memory; and yet an equivalent to the feat which I have supposed was actually accomplished by an obscure engineer in America 40 years ago. The country between London and Bristol is undulating, the Thames is crossed by Brunel's grand elliptic brick arches, and the same river, or one of its tributaries, further on. In approaching Bath, the oolite hills attain an elevation of about 500 feet above the Bristol terminus. The difficulty here is overcome by the box tunnel. On the American line from Charleston in South Carolina to Augusta in Georgia the Ashley, and the larger Edisto had to be crossed, and on approaching Augusta a range was met attaining at the summit an elevation of 505 feet above the station at Charleston. This the American engineer overcame by inclined planes, a stationary engine, and ropes, instead of a tunnel. Thus, it would appear, that the engineering difficulties of the two lines were about equal. The American line was projected in the year 1823, the surveys were made in 1830, the works commenced in 1831, and the line opened

for traffic in 1834. It has always been spoken of as in every way successful, if we except one expectation of its projectors which was not realized. It taps the Savannah river, but does not draw off the amount of traffic anticipated for the simple reason that, however cheap land carriage may be, water carriage is still cheaper. I should have stated that the length of the line is more than that from London to Bristol, viz., 136 miles, the latter distance being 118. I have purposely compared the Charleston and Augusta railway with the Great Western, as exhibiting almost the extremes as to cost, and yet in many respects bearing a resemblance to each other—in length of line, undulating nature of the country, and one or two engineering difficulties. The difficulty overcome by the box tunnel may be compared with that overcome at Aiken (on the Charleston and Augusta) by inclined planes and a stationary engine—the summit level at Aiken being, as before stated, 505 feet above the Charleston station, and the hill near Bath through which the box tunnel is excavated rising to an elevation of about 500 feet above the Bristol terminus. The earthworks upon both were necessarily considerable, in order to obtain sufficiently easy gradients; but the American engineer exercised much greater judgment and discrimination in the outlay of a very limited capital than his English brother, who found himself in possession of unlimited funds, with *carte blanche* as to their expenditure. The American engineer did not, like certain English engineers designated in the leaders of the *Times* as belonging to the “fast” school, evade his grading, under the erroneous assumption, ignoring the cost, that there was no practical limit to the power of the locomotive, but very judiciously expended about one-third of his whole capital (a very much greater proportion, be it observed, than Brunel expended upon the grading of the Great Western,) in order to make his line as theoretically perfect in grades as his very straitened circumstances would allow, and thus reduce the weight of engine necessary to draw a given load, and consequently the cost of transit per ton per mile. Having arranged his gradients, he found himself necessitated to keep the cost of his permanent way within £525 per mile, the actual cost being as before stated £524 18s. 5d. per mile, as the purchase of land, erection of station buildings, stationary engine at inclined planes at Aiken, fuel and watering depôts at intervals along the line, 15 locomotives, 14 passenger cars and 90 goods wagons, erection and furnishing of workshops &c., &c., absorbed £419 per mile of the capital. Although the permanent way cost only the very small amount above stated, the maintenance of way must have been a very small item when the total working expenses came to only £294 per mile per annum. The engines employed to work the line weighed less than eight tons each, and rested upon six wheels. I have purposely referred to this line in order to show how the apparent incompatibility of easy gradients, with cheapness of construction, was met by the engineer of the Charleston and Augusta line, and carried to a practical issue before the Great Western (of England) was commenced, and while the expensive plans for the latter were in course of preparation. The final results were, a complete success in the case of the railway with small traffic, and a comparative failure in the case of the railway with large traffic. The name of the engineer who so ably constructed this remarkably cheap line in the very earliest days of railway enterprise, I daresay has never been heard by any now in this room. I think it ought to be rescued from oblivion. His name was Horace Allen, and I think that name ought to stand as high in the annals of civil engineering as either Stephenson or Brunel.

In the *Engineer* of February 26, 1860, there is an article on the “Light Rolling-Stock System,” in which a description is given of Mr. Fairlie’s combined engine and passenger carriage, the whole weighing only 14 tons, with accommodation for 90 passengers. (Such a combined engine and carriage, working with a consumption of only 10 lbs. of fuel per mile, and sufficiently powerful to draw upon the easy gradients of the City and Port Railway two or three other carriages after it, would I submit, be ample for the passenger traffic of that line.) And in the same article there is reference made to certain light engines built for the passenger traffic upon the Cork and Bandon Railway, 5 feet 3 in. gauge, of which the following particulars are given from the engineer’s report:—

“The passenger trains are conveyed by the ‘light’ or small engines, which continue to afford most satisfactory proof of their efficiency and and economy in working the passenger traffic on your line.”

“The trains frequently consist of the following stock, all fairly laden:—

“One large first and second class carriage for 58 passengers.

“One third class carriage for 40 passengers.

“One horse-box for three horses.

“One carriage truck.

“Such trains are conveyed between Bandon and Ballinassig station in twenty minutes, being at the rate of 30 miles per hour, including stoppages, (gradient $3\frac{1}{2}$ miles, 1 in 100, total distance 10 miles.)

“The daily consumption of coke for each of these engines has been most particularly registered by your able station-master at Bandon, Mr. Coghan, from whose returns I find the average quantity of Newcastle coke consumed per diem as follows:—

	Consumed in lighting the engine,	time occupied two hours	Consumed standing in steam, time occupied eight hours	Consumed in running 60 miles, time occupied two hours
	2	0	2	1
	16	1	17	3
				26

Total daily consumption, cwt. 6 2 3
“Which is equivalent to 12 one-fifth lbs. per mile per day of 12 hours, but it will be seen that the running time is only two hours, during which the consumption is not more than $3\frac{1}{2}$ lbs. per mile.

“The average daily consumption of the Company’s ordinary-sized engine with the same work is 22½ lbs. per day, or nearly double that of the light engines; and the same difference also arises between the two classes of engines in the consumption of oil, grease, &c., so that an important saving has been effected in the working expenses by the adoption of engines whose powers and dimensions are in proportion to the loads they are required to convey.”

These engines are not much heavier than those I have mentioned as used upon the Charleston and Augusta Railway. They weigh $8\frac{1}{2}$ tons empty, carrying water and fuel on their own frame.

The Dublin and Kingstown Railway was for many years in a very bad financial position, but several years ago the directors adopted very light rolling-stock on that line, and the shareholders have ever since received dividends of from 9 to 10 per cent. upon the original share capital. It is in England alone, where the so much vaunted principle of “private enterprise” has had full sway, that railways have been a complete failure, not only as regards the shareholders in the speculations, but also as regards the travelling public. “They manage these things better in France.” There the railways pay from 14 to 17 per cent. upon capital. The City article of the *Times* April 27, 1868, says:—“Some lessons in management may be learned from the

French lines. Strict attention is there paid to little things. The pence are scrupulously cared for, and the result is that the pounds take care of themselves.” In Belgium the public are carried long distances for one quarter of what they would have to pay in England for the same class, while the railways yield a large revenue to the state. If private enterprise without a guarantee has been such a thorough failure as the preceding parts of this paper have shown, I am at a loss to comprehend what possible argument can be used in favour of guaranteed companies in the colonies.

I must now bring this somewhat lengthy paper to a conclusion, and will do so by quoting a paragraph from the letter before referred to:—“The Americans metamorphosed the English railway system into one well adapted to the wants of their country. We have twenty-seven years (now forty years) of their experience to guide us; and I am not aware that we have not men of as great ability amongst us now as they had amongst them in the year 1830. If the Parliament insists upon economy, I have but little doubt but that we shall be able to develop a railway system in this province as superior to that of the United States as that is superior to the English system in economy of construction and management. We ought to be able to profit by their experience, and to avoid their errors; and in so doing I have no doubt that we may be able to devise and carry to a successful issue a comprehensive scheme that shall not cost more than I stated in my address to the electors of the Encounter Bay district, namely, £5,000 per mile.”

In setting down £5,000 per mile as a fair average for a system, or network, of railways for the whole province, I of course assume that the easier lines ought to be constructed for very considerably under that sum, and that some lines, or portions of lines where there are engineering difficulties, will necessarily cost three or four, or even five or six, times that amount.

NOTE.—The foregoing paper (although much is omitted that I at first contemplated inserting), I confidently submit, establishes the following points:—

1. That railways have been constructed both in Europe and America at about the cost of a good macadamized road.

2. That upon such cheaply constructed lines in America in the earliest days of railway locomotion, a traffic of only about 5,000 tons of goods and 34,000 passengers per annum was carried at a cost to the public of $£444 \times 136 = £60,384$, or (reckoning the same charge per passenger per mile as per ton of goods) at an average of less than 2½d. per mile; and at a cost to the proprietors of the line of $£294 \times 136 = £39,984$, leaving a profit of £20,400, or between eight and nine per cent. per annum.

This rate 2½d. (two pence three farthings) per mile, be it observed, though below the cost of transit upon common roads, is considerably above the cost of railway transit in America in the present day.

3. That upon the cheap railway in Westphalia a goods traffic of 32,709 tons in 1866 was carried at a cost of 1.63d. (one penny and sixty-three hundredths) per ton per mile to the public, and at a cost of 0.79d. (seventy-nine hundredths of a penny) to the proprietors of the line, leaving them a profit of six per cent.

From these facts I infer that it may be possible to construct and work lines in Australia upon somewhat similar or analogous principles, and that the two questions which I proposed to discuss in the beginning of the above paper may be answered in the affirmative. If not, those who take the adverse view ought to be able to show, Why not?

SUBJECT—"THE CAUSE OF DISEASE IN SILKWORMS."

MR. CHAIRMAN, AND GENTLEMEN—

The following highly important and interesting subject I found lately in one of the German scientific journals, and I considered a translation of it of great importance, at least to our sericulturists: It is known to you that the appearance of the disease of the silkworm which makes such fearful ravages amongst the worms in Europe is unknown in China and Japan, their native country. It was naturally that the attention of scientific men would be called to the subject, with the view of ascertaining the cause of the disease as well as a remedy. Amongst the endeavours to analyze the chemical constituents of the leaves of the mulberry, the experiments of Dr. Reichenbach made in the laboratory of Baron Leibig, are considered the most prominent. A French naturalist had already observed that silkworms, if not fed sufficiently, were subjected to a disease and produced a weak progeny which were almost useless. Dr. Reichenbach then tried whether the leaves of the mulberry grown in Europe contained the necessary nourishment in sufficient quantities. Physiology teaches us that nutritive substance which does not contain all the necessary ingredients in corresponding proportions operates as injuriously as food would, if insufficient in quantity. For example,—he who takes in his food none or very little matter containing nitrogen is under the same disadvantage as another who takes normally composed food, but insufficient in quantity. To this may be added the fact, that the silkworms never get the disease in their native country, whilst in Europe the disease is very prevalent; and this confirms the supposition that in China and Japan the leaves of the mulberry contain chemical properties which those in Europe are deficient. Dr. Reichenbach, to decide the question, examined eight different kinds of mulberry leaves, two from Japan, one from China, three from Piedmont, one from France, one from Breszia, and defined the quantity of nitrogen they contained. This varied very considerably in the different kinds; 1,000 pounds of mulberry leaves from China, Japan, and Breszia contained 204 pounds of nitrogenous matter, whilst 1,000 pounds of Italian and French leaves contained only 148 pounds of nitrogenous matter. It is well known that it is the nitrogen or albumen which is the important ingredient, and to obtain this for the development of the worms it is necessary they should eat a larger quantity in proportion. But to receive the same quantity of nitrogen which the worms receive by the eating of 1,000 pounds of leaves in China and Japan, they

would require to eat 1,378 pounds of leaves in France and Italy. Other matters essential to nourishment in the several leaves were discovered, namely, phosphoric acid, salt, and magnesia. The phosphoric acid showed a very interesting combination with the substance of nitrogen. It was contained in greater abundance in the leaves from China and Japan than in those from Italy and France, and 1,000 pounds of Asiatic leaves contained as much phosphoric acid as 1,378 pounds of European. Still more unfavorable was this proportion of the two kinds of leaves relative to the contents of salt and magnesia. Even 1,378 pounds of European leaves do not give the worms the quantity of salt which they receive by eating only 1,000 pounds of Asiatic leaves. These proportions discovered by minute chemical researches show very clearly that the composing part of the European leaves are greatly different from those of the Asiatic. The quality of the former is insufficient for the nourishment of the worms introduced from China and Japan, which are accustomed to a nourishing food not to be obtained in the European leaves, and are consequently unable to produce an equally strong posterity, and so the second and third generation are subjected, as it is said, to disease. Although the problem of the disease of silkworms is not entirely solved for there are besides other noxious influences to which these worms are subjected, it has been proved by the researches of Dr. Reichenbach that the silkworms receive insufficient food from the European leaves, and it is a most important task for the breeder to remedy the defect by all means under his control. The object therefore is to give the European leaves the necessary matter for nourishment. First of all, practical men must direct their attention to the leaves from Breszia, as it is shown by the investigation made thus—they contain the same proportion of nitrogen as those from Asia. Then we must not forget that the leaves from Breszia were young and green and in their full vigour of growth; it will therefore be necessary to prove whether the ingredients of nourishment contained in those leaves would appear so favourable at a later period. Is this not the case—then their nourishment must be produced by suitable manuring in order to supply nitrogen. A most important and valuable point has been shown by Dr. Reichenbach; the nitrogen was always existing in the same proportion as the phosphoric acid; the more phosphoric acid the more nitrogen was found, the less phosphoric acid they contained, the less nitrogen was found in the

leaves. That the one proportion in which the matter increased was also the same with the other one, leads us to conclude that there is a close connection in both of those substances and we must also infer that through the supply of phosphoric acid as manure, the plants will also contain more nitrogen. The first trials should therefore be made by manuring with phosphoric acid, which would be of the highest importance for the culture of silkworms. A most important question in regard to sericulture in South Australia will now be, do our mulberry leaves contain sufficient nourishment for the silkworm as those in China and Japan? To ascertain this a similar investigation should at once be made with our mulberry leaves, and I think there is not an abler man in the colony to carry out the task than my friend Mr. Francis. This gentleman is always ready to devote his time aiding scientific investigations, and as he himself is a most enthusiastic disciple of sericulture, no doubt he will ascertain the important fact from which will depend in a great degree the success of sericulture in South Australia. I cannot omit to mention an important new fact in confirmation of my paper read the other day before the Society, namely "The influence of Forests on Climate." In 1866 Messrs. Brquerel (father and son), in France, published a series of observations, on the importance of forests on climate, and the great influence they have in regard to rain and temperature, and showed at the same time the injurious effects on the climate by cutting down the forests. In consequence, to test those observations, the French Government ordered to be made by the Forest Academy at Nancy, a series of meteorological observations in the neighborhood of forests, and also in plains denuded of trees. These observations were read the other day before the Academy of Science at Paris, and the result showed that during the time the investigation had been made one quarter more rain fell annually in the neighborhood of forests than in plains denuded of trees. It is further stated in regard to the temperature near forests—the forest effects the same equal temperature as the sea does along the coast, and that a great contrast in this regard was found in the temperature of plains. I remarked also in my paper that since the replanting of trees in the Delta of Egypt the rainy days had risen from six to twenty-four annually; but after later observations in Egypt, the rainy days have increased to forty days annually. It is also mentioned that the Viceroy Mehemed Aly had planted on the Delta twenty millions of trees.

SUBJECT—"SOME OBSERVATIONS ON THE RAINFALL AT ADELAIDE,

AND THE CONNECTION BETWEEN METEOROLOGICAL CHANGES AND THE YIELD OF WHEAT."

ABSTRACT OF RAINFALL—ADELAIDE.

On considering this subject, it appeared to me that the best way to illustrate it would be to put my facts into the form of curves, which, although not strictly accurate, inasmuch as it assumes that the change between consecutive observations is gradual and uniform, yet is sufficiently so for the purpose of showing the more striking relations between the facts on record. To the observations taken at the Adelaide Observatory by Mr. Todd, and to the preceding record of the rain gauge kept by Sir Geo. Kingston, on West terrace, I am indebted for my meteorological facts.

The meteorological year is generally if not universally made to commence on the 1st of January, but it seemed to me it would be better to commence it with the 1st of April, being nearly the time of the Sun's crossing the equator from South to North, as it is at the equinoxes that the chief changes in the winds occur; the meteorological year would thus commence with the beginning of our winter rains. The first two quarters would represent the winter rain, and the third the summer rain; thus the rainfall during the time of growth and the time of ripening of our cereals, would be well marked—the whole of the summer months also would be thrown together, instead of half of them being in one year's observations and the other half in the next series. I have accordingly adopted this division of the year.

The annexed table shows the rainfall for the 2nd, 3rd, and 4th quarters of each year and the first quarter of the following one, from 1839 to 1870, taken from Sir Geo. Kingston's and Mr. Todd's observations. To these I have added the rainfall for the whole meteorological year, as well as that of the six winter and six summer months. Lastly I have given the mean of the maxima monthly temperatures for some of these years; unfortunately the latter series is very incomplete. In the earlier part it begins in 1846 and continues with one intermission up to 1856—this part of the table gives the maximum temperature in the Survey office at Adelaide. After 1857 Mr. Todd's observations of the maximum in shade in the open air commence. It will be observed, as might be expected, that the former observations run about 10° below the latter, of course no comparison can be drawn between the heat of the years preceding 1857 and those following, and the temperature of each set can therefore only be compared with those of other years included in the same set,

Years.	2nd Quar. April, May, June.	3rd Quar. July, August, Sept.	4th Quar. October, Nov. Dec.	1st Quar. following year. Jan. Feb. March.	The Year.	Winter 6 months	Summer 6 months	Maxm M. Temp. in 6 summer months	
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Degrees.	
1838-9	—	—	4.823	1.749	—	—	6.572	—	
1839-40	4.121	7.745	6.225	2.782	20.873	11.866	9.007	—	
1840-1	5.936	9.369	5.910	1.610	22.825	15.305	7.520	—	
1841-2	7.600	5.626	3.120	2.095	18.441	13.226	5.215	—	
1842-3	6.259	6.791	5.173	1.340	19.563	13.050	6.513	—	
1843-4	5.760	6.552	3.540	1.325	17.177	12.312	4.865	—	
1844-5	4.663	9.110	2.750	0.734	17.287	13.773	3.514	—	
1845-6	6.855	7.461	3.780	3.135	21.231	14.316	6.915	—	
1846-7	8.010	9.010	6.790	1.808	25.618	17.020	8.593	—	
1847-8	12.212	8.535	3.530	0.965	25.302	20.807	4.495	94.7	In Survey Office.
1848-9	4.300	8.449	5.970	0.895	19.614	12.749	8.865	88.8	
1849-50	11.305	9.961	3.250	4.380	28.899	21.269	7.639	92.2	
1850-1	6.180	4.514	4.200	1.225	16.119	10.694	5.425	98.4	
1851-2	11.200	13.208	5.000	1.330	31.333	24.408	6.930	—	
1852-3	8.200	12.610	4.600	1.403	26.818	20.810	6.008	91.8	
1853-4	13.828	8.321	3.313	1.183	26.615	22.149	4.496	89.7	
1854-5	5.498	5.815	2.850	4.440	18.603	11.313	7.290	98.0	
1855-6	6.658	8.519	3.258	3.873	22.308	15.177	7.131	94.5	
1856-7	11.623	5.096	4.355	4.696	25.770	16.719	9.051	—	
1857-8	5.351	5.280	4.822	4.410	19.863	10.631	9.232	107.5	In open air in shd
1858-9	5.725	6.330	3.785	1.390	17.230	12.055	5.175	103.8	
1859-60	6.996	3.066	2.868	2.340	18.850	13.642	5.208	104.4	
1860-1	10.123	3.324	2.716	1.959	18.132	13.447	4.685	102.4	
1861-2	8.385	6.988	6.693	1.402	23.418	15.323	8.095	101.4	
1862-3	8.186	10.223	3.040	1.615	23.064	18.409	4.655	103.3	
1863-4	8.317	8.920	4.823	0.300	22.330	17.237	5.123	100.9	
1864-5	6.904	8.943	1.705	1.230	18.082	15.847	2.935	99.1	
1865-6	4.557	8.699	1.020	2.225	16.481	13.256	3.225	107.6	
1866-7	7.660	6.550	3.378	1.684	19.272	14.210	5.062	104.5	
1867-8	5.350	7.072	4.945	2.617	19.984	12.422	7.562	102.8	
1868-9	8.045	6.509	2.816	2.629	19.999	14.554	5.145	103.1	
1869-70	5.123	3.007	3.377	3.283	15.390	8.730	6.660	103.5	
1870-1	—	—	—	—	—	—	—	—	

In plate No. 1 these figures have been thrown into the forms of curves. It will be seen that the maximum rainfall in any one meteorological year was 31.333 inches in 1851-2. The minimum rainfall was 15.390 inches in 1869-70. The average of the whole 31 years being 21.009 inches. The average rainfall in the second quarter (April, May and June) was 7.449 inches; that in the third

(July, August and September) 7.490 inches, being very nearly the same as in the second; the fourth quarter (October, November and December), 4.014 inches; and the first quarter of the following year 2.146 inches. The average of the winter six months is 14.939 inches, and of the summer ones 6.160 inches. It will be observed of the winter rains that as a rule, except in notably dry years, such as the one we have just passed through, the deficiency of one quarter is generally made up by an excess in the other one and *vice versa*. The same remark holds good in the six summer months. Plate 1.—A comparison of the imperfect curves of temperature with those of rainfall brings out this fact, that whenever, as in 1850, 1854, 1857, and 1865 the average maximum monthly heat was high, the winter rains were considerably below the average; but low average monthly maxima temperatures although generally are not always preceded by heavy winter rains. Other curves to which I shall refer presently show that the curves of maxima monthly temperatures and of maxima daily temperatures follow each other very closely; we may therefore be justified in the absence of more perfect data in the conclusion that when the winter rainfall is deficient, the summer following will be likely to be a hot one.

On examining the curve showing the winter rainfall in plate No. 1, a remarkable oscillation is apparent extending over twelve years, from 1846 to 1857. Before 1846 and after 1857, the changes in the winter rainfall from year to year are much less, and the curves consequently more regular. As the curves of temperature and rainfall are closely allied, these oscillations in the rainfall indicate the presence of other atmospheric disturbances also, and seem to point to an influence external to our globe. It is now known that there are innumerable ærolite bodies moving in various directions in space, of which the November showers of shooting stars are an instance, and it is possible that our earth during these years passed through a space containing such bodies, variously distributed, whose joint influence may have affected our atmosphere, and causing unusual annual oscillations in it. Spectroscopic observations show us that some, at least, of the heavenly bodies consist of gaseous matter, and that is probably the case with many of the meteors, mis-called aerolites, which traverse space and which might even come in contact with our atmosphere and cause great disturbances in it, whilst they were themselves invisible to us and their near proximity quite unsuspected.

But let us leave the region of speculation and come down to that of sober facts, and endeavour to investigate the connection between the changes in our atmosphere and the yield of wheat in our fields.

It is not my intention in the present paper to attempt to enter into the effects upon vegetation of meteorological phenomena, but simply to bring into juxta position the recorded facts of meteorology, and the corresponding results in the shape of the wheat harvests.

As my data for meteorology were obtained from Mr. Todd's valuable series of observations at the Adelaide Observatory, it became necessary to limit my agricultural facts (for which I am indebted to the returns of the Government Statist) to the county of Adelaide, as it may be fairly assumed that the observations in its centre at Adelaide represent the general temperatures and rainfall of the district. The returns for the county of Adelaide do not extend further back than ten years; but upon comparing them with the returns for the whole colony which extend back for twelve years, I found so great a correspondence between them, that I was able so to speak, to interpolate the two missing years, and thus avail myself of the comparison between my agricultural and meteorological facts for the whole twelve years.

Of course the most obvious course in this enquiry was in the first instance to compare the winter rainfall, say from April to September inclusive, with the harvest yield, which is done in plate No. 2. As might be expected, the two

show a considerable relation to each other, but it is notwithstanding evident that there are other agents at work which exert at times at least a still greater influence than the winter rain. The average yield of wheat for the twelve years in question is 10.2 bushels per acre; and the average six months' winter rainfall for the same period is 14.1 inches of rain. The same average since 1839 to the present time being 15.2 inches, consequently the winter rain for these twelve years has been about one inch below the total average. The best harvest on our record, 14.5 bushels per acre, was in the year 1863, but in that year the winter rainfall only reached the mean of the twelve years we are considering; on the other hand, the worst harvest in that period does not correspond with the minimum of rainfall.

The average summer rainfall, October, November and December, which we may call the wheat's summer, during the twelve years was 3.43 inches. In the worst harvest which was in 1867 when the red rust was so bad, this summer rain was 4.9 inches, the yield at harvest being only 2.7 bushels. In 1861 there were unusual summer rains amounting to 6.7 inches, whilst the harvest was slightly above the average viz., 10.4 bushels. In the year 1866 when the harvest was the greatest, the summer like the winter rain was only about the average quantity. Finding that the curves of rainfall correspond so little with that of the yield, I thought further light might be thrown upon the influence of climate by comparing the temperature of each month with the yield of wheat. The diagrams 2, 3, 4 and 5 show this comparison for the months of June, July, August, September, October, November and December for the years in question; the upper curve represents in each instance the yield of wheat, being measured from below upwards, in the diagrams from July to September; but in the reverse way in those for October, November and December, that is in the latter months the higher the points of the curves the less the number of bushels of wheat. In all the other curves in the diagrams the measurements are from below upwards.

The second curves show the approximate mean temperature for the month for each year; the third the mean of the daily maximum readings of the dry bulb thermometer; the fourth the monthly maximum, and the fifth the humidity of the air as calculated from the readings of the dry and wet bulb thermometer. In these calculations 100 representing complete saturation of the air with watery vapour. The last curves show the rainfall for each of these months respectively.

Out of these twelve years I have selected for examination 1867, 1869, 1859, and 1865, the yield of which for the county of Adelaide was respectively 2.7, 6.3, 9.0, 9.3 bushels per acre, as representing bad harvests; and 1862, 1860, 1863 and 1866, yielding respectively 11.9, 13, 13.4 and 14.5 bushels per acre, as representing good harvests, the average yield of the whole twelve years being 10.2 bushels.

In order to compare these years one with another I have prepared the following table giving a comparison of the monthly temperatures with the yield at harvest. In order to bring everything to a common standard of comparison, I have assumed the maximum deviation with above and below the average of the twelve years to be five, and have reduced the other deviations from this average to the same scale.

The following were the good and bad years: June 1867-69-59-65 bad years; 1862-60-63-66 good years. July 1867-69-59-65 bad years; 1862-60-63-66 good years. August 1867-69-59-65 bad years; 1862-60-63-66 good years. September 1867-69-59-65 bad years; 1862-60-63-66 good years. October 1867-69-59-65 bad years; 1862-60-63-66 good years. November 1867-69-59-65 bad years; 1862-60-63-66 good years. December 1867-69-59-65 bad years; 1862-60-63-66 good years. Oct. Nov. Dec. 1867-69-59-65 bad years; 1862-60-63-66 good years.

N.B.—5 represents the maximum deviation from the mean of twelve years, 1853 to 1869.

COMPARISON OF MONTHLY TEMPERATURES AND HARVESTS.

Mnth	Yield of wheat		Mean Temp		Mean daily Max.		Mean mth Max.		Hum.		Rain-fall.		Six Mth Wnt Rain	
	above	below	above	below	above	below	above	below	above	below	above	below	above	below
June.	1867	...	5	...	5	...	3	...	1	...	5	...	1	...
	1869	...	3	...	...	...	1	...	4	...	...	...	5	...
	1859	...	...	...	5	...	5	...	5	...	...	...	1	...
	1865	...	...	...	1	...	...	...	1	...	...	...	...	...
	1862	2	...	...	1	...	1	...	...	...	2	...	5	...
July.	1860	3	...	...	...	...	2	...	5	...	4	...	...	...
	1863	4	...	...	...	...	2	...	3	...	1	...	...	...
	1866	5	...	...	...	...	4	...	...	...	...	...	...	...
	1867	...	5	...	1	...	2	...	...	...	...	...	1	...
	1869	...	3	...	...	...	...	...	5	...	...	...	5	...
August.	1859	...	...	...	5	...	...	...	1	...	...	...	1	...
	1865	...	...	...	2	...	...	...	...	...	...	...	...	...
	1862	2	...	...	3	...	...	...	...	...	...	...	5	...
	1860	3	...	...	6	...	...	...	...	...	...	...	...	...
	1863	4	...	...	1	...	...	...	4	...	4	...	...	...
September.	1866	5	...	...	...	...	1	...	3	...	2	...	...	...
	1867	...	5	...	...	...	5	...	4	...	3	...	...	...
	1869	...	3	...	...	...	3	...	...	...	5	...	...	...
	1859	...	...	...	...	...	1	...	...	...	...	...	5	...
	1865	...	...	...	...	...	...	...	1	...	...	...	...	...
October.	1862	2	...	...	...	...	...	...	...	...	...	...	...	...
	1860	3	...	...	...	...	...	...	...	...	...	...	...	...
	1863	4	...	...	...	...	...	...	...	...	...	...	...	...
	1866	5	...	...	...	...	...	...	...	...	...	...	...	...
	1867	...	5	...	...	...	5	...	1	...	...	...	...	...
November.	1869	...	3	...	...	...	...	...	2	...	...	...	...	...
	1859	...	...	...	...	...	...	...	...	...	...	...	...	...
	1865	...	...	...	...	...	...	...	...	...	...	...	...	...
	1862	2	...	...	...	...	...	...	...	...	...	...	...	...
	1860	3	...	...	...	...	...	...	...	...	...	...	...	...
December.	1863	4	...	...	...	...	...	...	...	...	...	...	...	...
	1866	5	...	...	...	...	...	...	...	...	...	...	...	...
	1867	...	5	...	...	...	3	...	4	...	...	...	...	...
	1869	...	3	...	...	...	...	...	...	...	...	...	...	...
	1859	...	...	...	...	...	...	...	...	...	...	...	...	...
Oct. Nov. Dec.	1865	...	...	...	...	...	...	...	...	...	...	...	...	...
	1862	2	...	...	...	...	...	...	...	...	...	...	...	...
	1860	3	...	...	...	...	...	...	...	...	...	...	...	...
	1863	4	...	...	...	...	...	...	...	...	...	...	...	...
	1866	5	...	...	...	...	...	...	...	...	...	...	...	...

I have already referred to the influence of the winter rains upon the yield of wheat; this table shows it very clearly, the rainfall of the winter.

preceding the four bad harvests being in every case below the average of the four good harvests, the winter rains of two of them are considerably above the average, marking four and five. The winter rains of the other two, however, scarcely come up to the average. In order to observe the effect of temperature and humidity it will be best to consider each month separately.

In the month of June the mean temperature and the daily maxima seem pretty equally divided between the good and bad years; the monthly maximum is generally above the average in the bad years and below it in the good years. A high maximum heat is no doubt prejudicial at this season, as it would be likely to kill the tender wheat plants which would be just springing up, and our meteorological facts tell us what any practical farmer would at once admit; the humidity is pretty equally divided between good and bad years, but the rainfall is below the average in the four bad years, dry weather doubtless injuring many of the young plants.

The table shows that in July, when the plants are stronger they require more heat; the mean temperature, the daily and monthly maxima, being all above the average in the four good years, and generally but not invariably below the average in the bad years; humidity and rainfall in this month being pretty equally divided do not appear to exert any very marked influence one way or the other.

In August it happens that the temperature of both bad and good years are above the average, so that the temperature of the remaining four years, when the harvests were about average ones, must have been very low. Although the temperatures do not show any marked influence, it will be observed that the humidity and rainfall of the four bad years were both deficient in this month. The same thing applies to September; the heat was pretty equally divided between the good and bad years. There was more humidity in the good years

than in the bad, and the rainfall although below the average generally was more deficient in the bad than in the good years, with the exception of the worst year 1867, when the month's rainfall reached the maximum. This excessive rain probably stimulated the wheat plants to an unnatural growth, which made them the more readily fall victims to red rust in the following month.

October in the table shows the advantages of a warm mean temperature and a moderate degree of humidity. In 1867 the humidity was above the average, and the rainfall was a maximum, circumstances which produced favourable results in the good years because accompanied by a mean temperature above the average; but in 1867 the mean temperature was only an average one, whilst the daily maxima were greatly below the average.

An examination of Mr. Todd's returns showed that the maximum for each day varied very much during this month, being as low as 58.9 on the fourth of the month, and 94.1 on the 23rd, the last day being followed by a maximum temperature of 76.5 with the mean humidity of 68.

The average humidity of this month for twelve years was 59.7. Mr Todd in his able report to the Red Rust Commissioners points out the great changes in this month from cold to heat, and of hot days with humid sultry nights as being very favourable for the development of the spores of red rust.

An inspection of the table of November shows that the best harvests were accompanied by temperatures below the average and by humidities above the average. November of 1867 does not show any very marked peculiarities; the mean temperature was very nearly up to the average, and there were no extremes of temperature to scorch the wheat, 96.8 being the maximum; so that the probability is that the real mischief was done in October, and that it was the abnormal condition of that month to which we are mainly

to attribute the disastrous failure of that year's harvest.

In December the mean temperature of the good years exceeded that of the bad years, but the monthly maximum (accompanied as it usually is with hot winds,) of the bad years on the other hand exceeded that of the good years, whilst the humidity and the rainfall seem to be pretty equally divided between bad and good years.

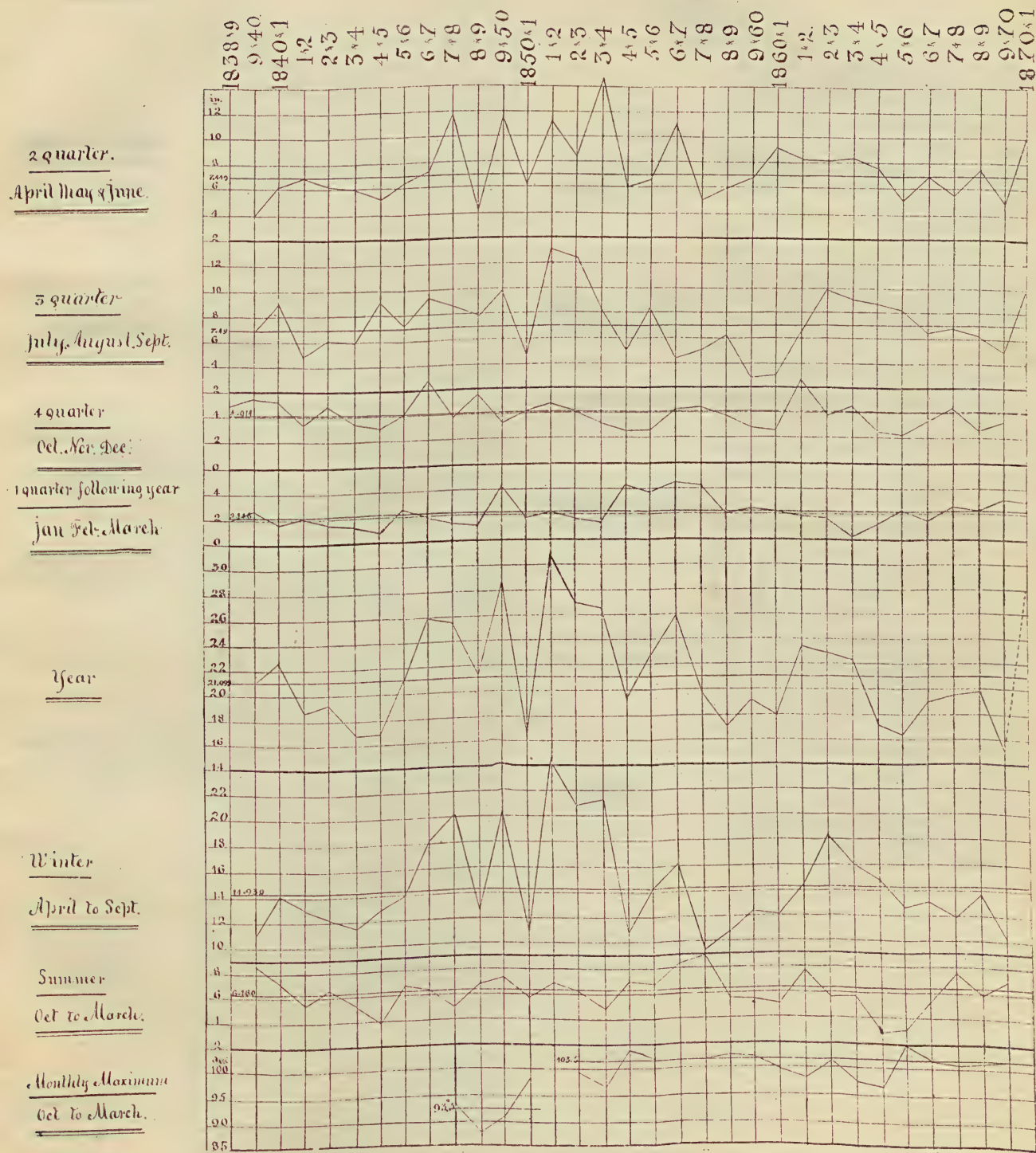
The last part of the table gives a view of the general effect of the meteorological changes upon the yield of wheat, taking the three months of October, November, and December, during which the wheat is ripening. A mean temperature above the average, lower daily and monthly maxima, and greater humidity prevail in the good years than in the bad ones, whilst the rainfall seems to be pretty equally divided between good and bad years.

It is remarkable that the best harvest on record was preceded by only an average amount of winter rain; and it shows how favourable temperature and humidity may ameliorate the effect of deficient winter rain and notwithstanding it brings the wheat to perfection.

I should have much liked to have traced the influence of ozone on the wheat crops, but unfortunately we have not as yet sufficient data in this colony to study this point, as the amount of ozone in the atmosphere has only been taken here during the last three years.

Another very interesting branch of this enquiry would be to endeavour to ascertain the effect of the meteorological changes upon the public health. This might be done by laying down the Registrar-General's observations in the shape of sanitary curves, and comparing them with the meteorological ones which I have given with this paper; should this not be done meanwhile by an abler person, I may possibly, should I be spared to return from the overland telegraph expedition, take up the subject at a future time.

CURVES SHOWING THE RAINFALL SOUTH AUSTRALIA



OCT. NOV. DEC.

Yield of Wheat.

Winter Rainfall.

April to September.

Approx^m mean temp^t

Oct, Nov, Dec.

Mean of daily maxima

Oct, Nov, Dec.

Maximum of month

Oct, Nov, Dec.

Mean degree of humidity

Oct, Nov, Dec.

Rainfall

Oct, Nov, Dec.

Yield of Wheat

Reversed

PLATE 2

JUNE.

Yield of Wheat.

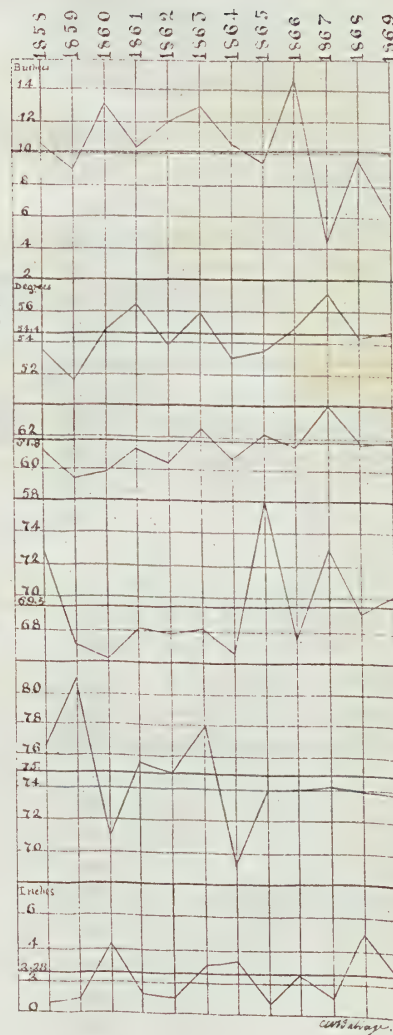
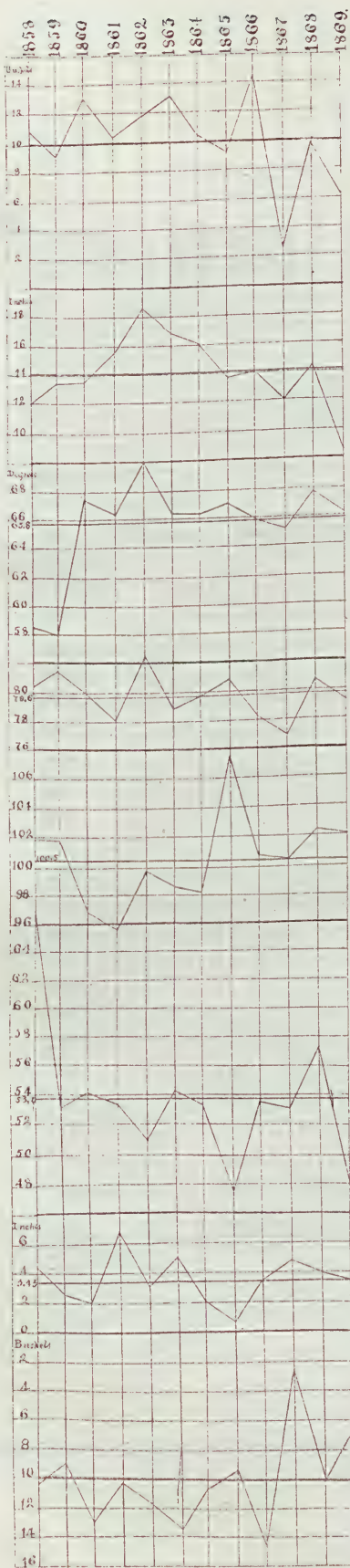
Approx^m mean temp^m

Mean of daily max^m

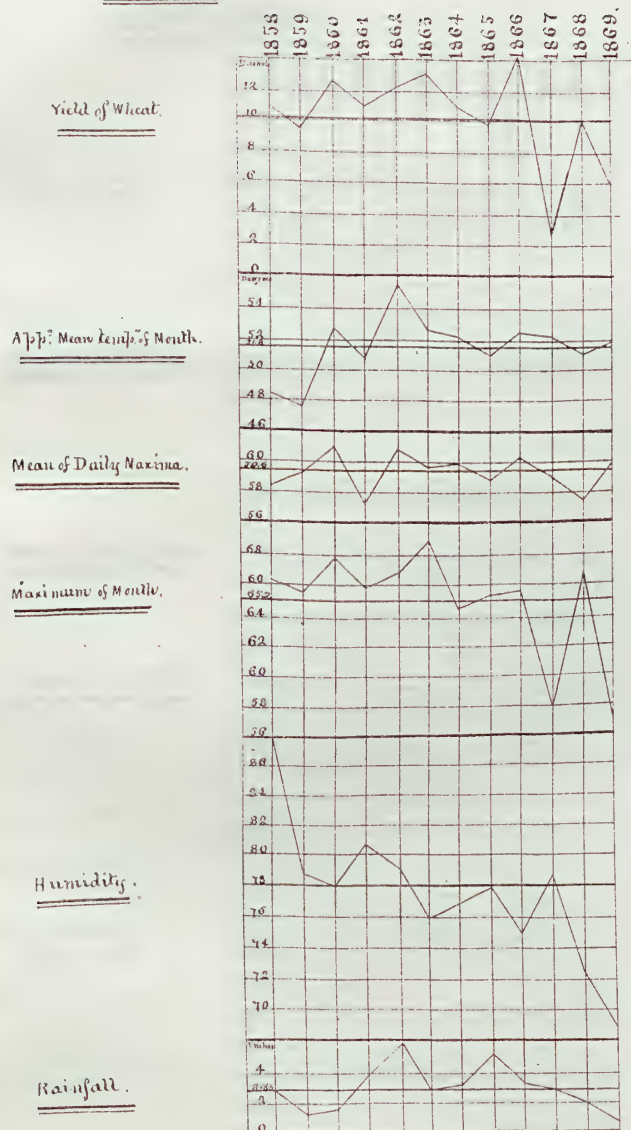
Maximum of month

Degree of humidity.

Rainfall.



JULY.



AUGUST.

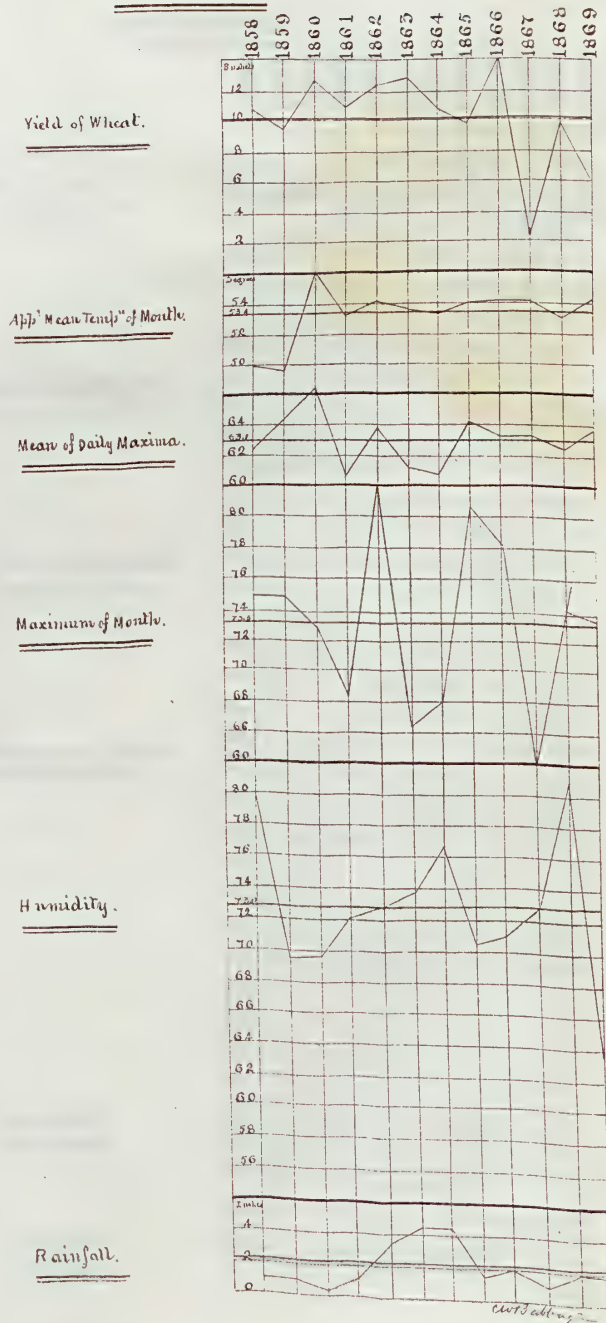
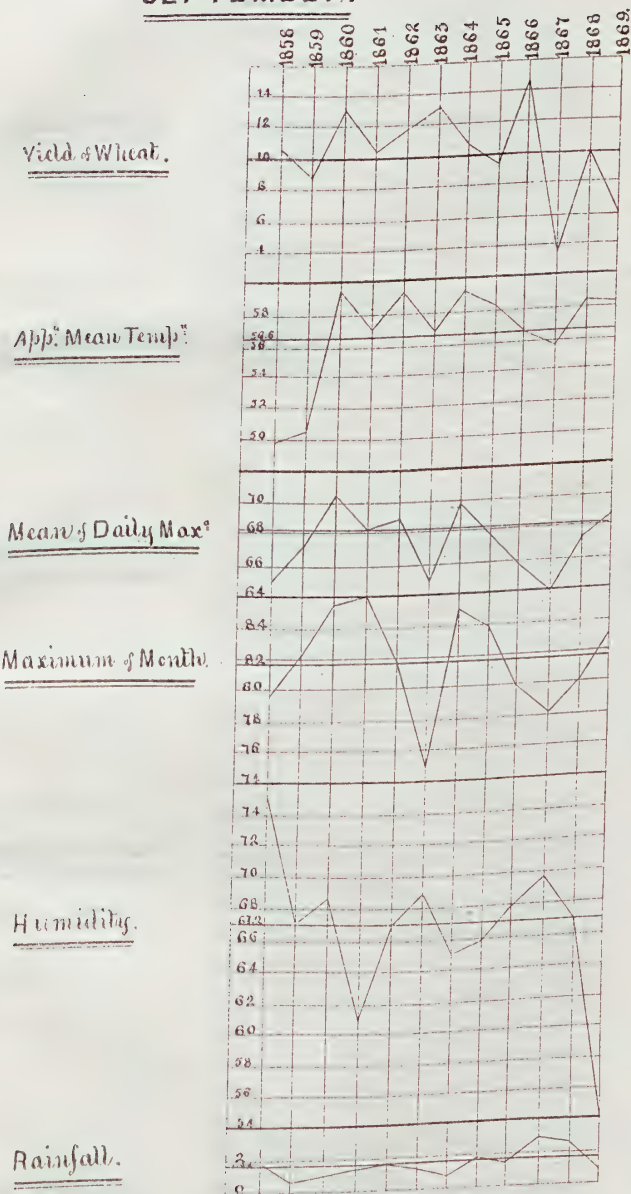


PLATE 4

SEPTEMBER.



OCTOBER.



NOVEMBER.

DECEMBER.

Yield of Wheat
Reversed.

Yield of Wheat
Reversed.

App. Mean Temp.

App. Mean Temp.

Mean of Daily Max.

Mean of Daily Max.

Maximum of Month.

Maximum of Month.

Degree of Humidity.

Degree of Humidity.

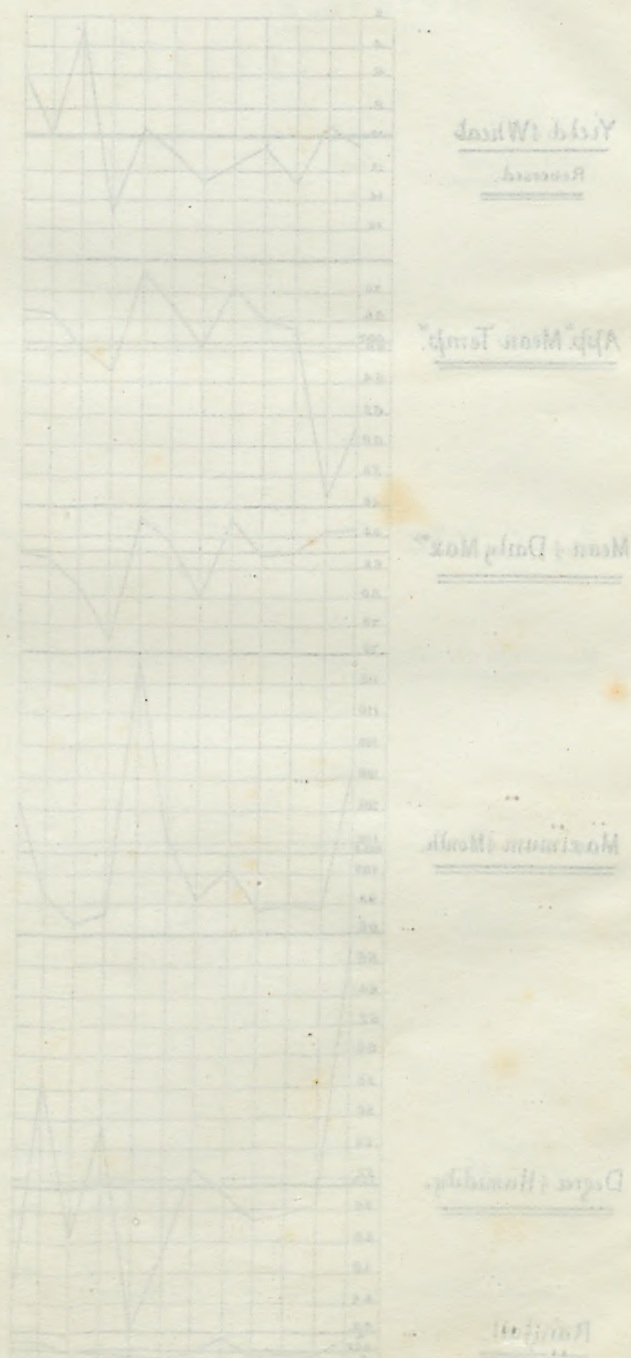
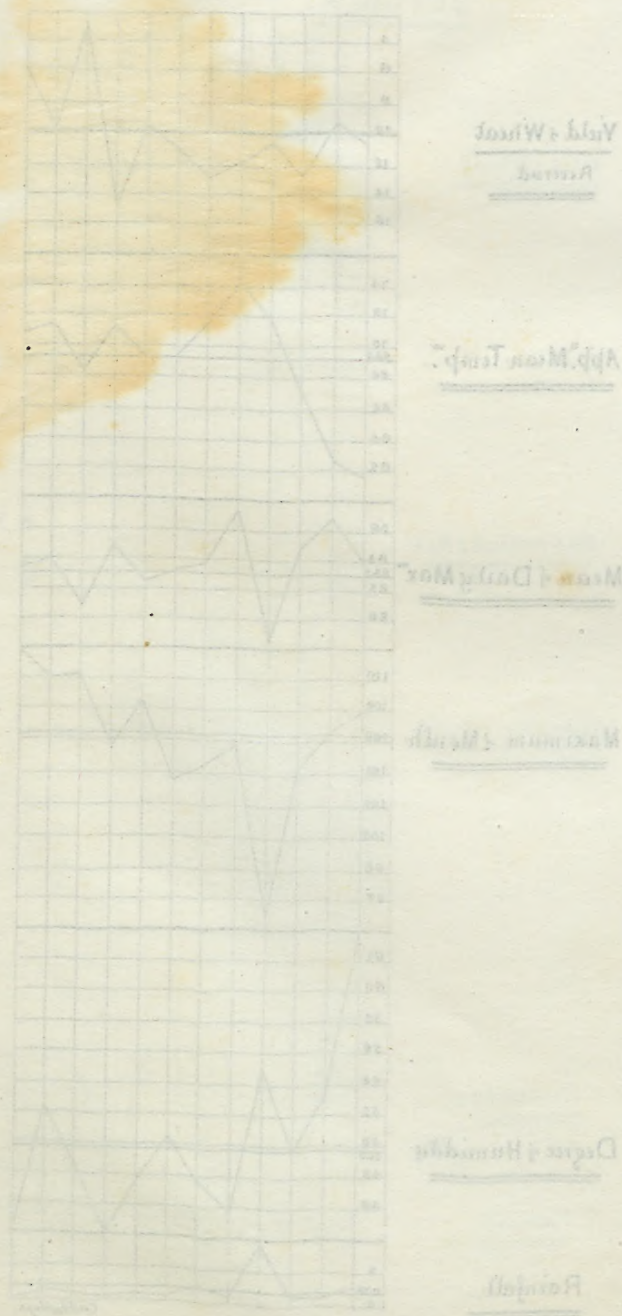
Rainfall.

Rainfall.

cut by page.

DECEMBER.

NOVEMBER.



new slip



P
506
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MAIN A7